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Design Schematics for a Sustainable Parking Lot

Building 2-2332, ENRD Classroom, Fort Bragg, NC

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Construction Engineering Research Laboratory

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Final Report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit # CNE, “Provide Concept Design and Review of Fort Bragg Buildings”

ABSTRACT: Standard parking lots constructed with traditional techniques of impervious pavement (typically concrete and asphalt) are associated with a host of inherent problems: runoff problems, heat buildup, air pollution, light glare, and poor aesthetics. When planners at Fort Bragg, NC identified the need for a new parking lot for an installation classroom building, the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) was tasked with planning a sustainable design "charrette" to explore and develop alternative parking lot designs that would meet Fort Bragg's parking needs, as well as its need to meet sustainable design requirement and to alleviate the installation's water runoff problem. This effort provided four design schematics for a sustainable parking lot to meet classroom needs and design sustainability requirements, and recommended strategies for incorporating sustainable design into the overall project site.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

***Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

Preface

This study was conducted for the Directorate of Public Works, Fort Bragg, NC under Reimbursable Work Order No. W31XNJ12731590/PO, Work Unit CNE, Task QD41, "Provide Concept Design and Review of Fort Bragg Buildings," The technical monitors were Paul Wirt and Dr. Christine Hull, AFZA-PW-EE.

The work was performed by the Land and Heritage Conservation Branch (CN-C) and the Environmental Processes Branch (CN-E) of the Facilities Division (CN), the Engineering Processes Branch (CF-N) and the Energy Branch (CF-E) of the Facilities Division (CF), Engineer Research and Development Center Construction Engineering Research Laboratory (ERDC-CERL). The ERDC-CERL Principal Investigators were Michelle J. Hanson, CN-E, and Annette L. Stumpf, CF-N. Dr. Kumar Topudurti is Chief, CEERD-CN-E; Lucy A. Whalley is Chief, CEERD-CN-C; Donald K. Hicks is Chief, CEERD-CF-N; and Dr. Thomas Hartranft is Chief, CEERD-CF-E. John Bandy is Chief, CEERD-CN, and L. Michael Golish is Chief, CEERD-CF. The CERL technical editor was William J. Wolfe, Information Technology Laboratory. The associated Technical Director is Dr. Paul A. Howdyshell, CEERD-CV-T. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL John Morris III, EN and the Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

Standard parking lots constructed with traditional techniques of impervious pavement (typical concrete and asphalt) are associated with a host of inherent problems. Parking lots constructed of impervious pavement often create runoff problems, especially when the local drainage system is at or near maximum capacity. Standard parking lots contribute to heat buildup ("heat island effect"), air pollution, light glare, and poor aesthetics.

Installation planners at Fort Bragg, NC identified the need for a new parking lot for the classroom building at Building #2-2332, outside the perimeter fence of the Public Works Business Center (PWBC) compound. This 60-space lot will accommodate students and teachers at all hours of building operation.

However, stormwater runoff, which contributes to increased flooding and to water pollution, has been identified as a major problem at Fort Bragg. Since traditional parking lot building techniques would almost certainly exacerbate this problem, the installation tasked the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) with planning a sustainable design "charrette" (a group brainstorming process in which participants from differing disciplines and backgrounds share in the design process) to explore and develop alternative parking lot designs that would meet Fort Bragg's parking needs, as well as its need to meet sustainable design requirement and to alleviate the installation's water runoff problem.

Objectives

The objectives of this project were to:

1. Provide design schematics for a sustainable parking lot adjacent to Building at 2-2332, Fort Bragg, NC, to meet classroom needs and design sustainability requirements
2. Recommend strategies for incorporating sustainable design into the overall project site.

Approach

A sustainable design charrette was held 11 December 2001 at Fort Bragg, NC to assess current sustainable design strategies and technologies and their possible implementation into the parking project. The charrette included personnel from Fort Bragg, from the Corps of Engineers Omaha (Transportation Center of Expertise) and Savannah Districts, and researchers from ERDC/CERL. The group was composed of members representing the following organizations/areas of expertise:

Fort Bragg

- Fort Bragg PWBC, Environmental Compliance Branch (ECB) (4 individuals)
- Fort Bragg PWBC, Erosion Control and Water Quality Branch
- Fort Bragg PWBC, Construction and Design (2 individuals)
- Fort Bragg PWBC, Master Planning
- Parsons, Inc.

Savannah District

- Savannah District, Site Development and O&M Section, Design Branch

Omaha District

- Omaha District, Transportation Systems Center of Expertise

ERDC/CERL

- ERDC/CERL Energy Branch
- ERDC/CERL Engineering Processes Branch (2 individuals)
- ERDC/CERL Environmental Processes Branch (2 individuals)
- ERDC/CERL Land and Heritage Conservation Branch

The group focused on how to infuse sustainable design strategies into parking design and construction for this project and as a demonstration for similar projects at Fort Bragg. The charrette defined project elements in three areas:

- Project design goals were explicitly stated (Chapter 2).
- Sustainable design strategies were outlined according to the principles expressed in the SPiRiT Sustainable Project Rating Tool, Chapter 3) (mandated for use by all Army construction projects and major renovations in ETL 1110-3-491, *Engineering and Design, Sustainable Design for Military Facilities** (Headquarters, U.S. Army Corps of Engineers [HQUSACE], 1 May 2001).

* available through URL: http://www.usace.army.mil/inet/usace-docs/eng-tech-ltrs/etl1110-3-491/toc.htm.

- Four alternative parking lot designs were conceived and drawn (Chapter 4).
- Conclusions and recommendations were drawn, with regard to the parking lot designs and regarding the charrette process itself.

Scope

The scope of the current project was limited to providing initial conceptual and design information that installations can use to sustainable parking lots. Specifically, this work was undertaken to define and describe "what makes up" a sustainable parking lot, to document the charrette process and the goals set forth at Fort Bragg, and to present and explain several CERL designs for a sustainable parking lot.

Mode of Technology Transfer

The results of this study will be delivered directly to Fort Bragg to support that installation's overall environmental sustainability goals (listed in Appendix A).

This report will be made accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 Project Design Goals and Charrette Notes

Site Description

The project site for the proposed parking lot is located at Fort Bragg, NC, Building 2-2332 in the SW corner of the PWBC. Building 2-2332 is approximately 500 ft west of the Butner Road and Reilly Street intersection. The project site is mostly flat, with a slight slope of about 2 to 3 ft downward to the southeast. The project area east of the classroom is paved to accommodate the PWBC compound entrance. The PWBC compound is generally behind the classroom (north) and consists of several buildings and outdoor facilities such as wash and gear racks, fueling stations, and service vehicle parking. Traffic enters and leaves via the compound gate entrance at Butner Road. Traffic consists of large trucks (H-20 load), buses, and automobiles. The subgrade soils at the project site are moderately conducive to water drainage as they are generally consist of slightly silty to silty sands with occasional seams of clayey sand.

Project Goal

The primary goal of the project is to provide functional parking for students attending classes at the classroom and to provide landscaping for areas around the building. These areas should be aesthetically pleasing, fit in with other surroundings, and incorporate sustainability principles. Maintenance costs for the proposed designs must also be considered. Stormwater run off is a significant problem for the installation. Consequently, the Environmental Compliance Branch (ECB) at Fort Bragg considered this project as an opportunity to try new concepts and to aggressively look for cutting edge technologies. Ideally, Fort Bragg would like to see a solution that shows both new construction and as well as ways to retrofit existing parking spaces.

Sustainability Design Goals

Specific sustainability design goals were to produce design alternatives that:

- ensure no stormwater runoff from the project site based upon a 25-yr, 24-hr storm event
- has no impact on existing stormwater system
- treats pollution from runoff
- includes a shaded parking lot
- has no energy needs
- requires little or no maintenance.
- produces zero waste
- controls soil erosion
- creates a positive natural habitat
- provides the installation with an outdoor education site
- is visually pleasing
- incorporates force protection standards
- uses existing recycled materials
- uses locally manufactured products (within 100 miles)
- provides an environmentally friendly classroom break area.

Site Design Parameters

Specific design parameters for this site were to:

- ensure parking for approximately 60 people (49 students and 11 instructors)
- allow trucks to enter the Public Works compound from the Butner Road entrance and proceed through the compound to the loading dock at the northeast corner of Building 31634
- allow semis and other large equipment to access the compound via the Butner road entrance and make the turn to get around Building 32039
- allow hazardous waste traffic to access the hazardous waste yard at Building 32039
- ensure that privately-owned vehicles (POVs) for existing PWBC buildings can use existing parking lots
- allow room for bus traffic in the new parking area for drop-off and pickup
- ensure that the total design/construction budget not exceed $500K.
- consider that possible soil contamination may be present
- ensure that force protection standards for standoff distances to parking and for visibility to buildings apply

- accommodate the fact that the classroom building and parking lot will be located outside the PWBC security fence
- recognize that adjacency conflicts may exist with the wash rack and cable tunnel near the building.

Parking Lot Charrette

The group took a tour of the facilities to look over the current parking and lot layout. It was noted that a lot of paved surface was available for parking. If the space is redesigned and/or reorganized, it may be able to accommodate student parking on existing pavement. During the afternoon discussion, the possibility of a policy change requiring PWBC employees to park POVs in a certain parking lot was considered. This policy change would free up existing pavement for use by environmental students and future Corps office visitors. While this policy change might require certain individuals to walk further from their cars to their office, it would be an environmentally beneficial practice.

The group split into smaller groups to come up with designs for three options for entry into the compound, based on the need to move the entry to the parking lot to: (1) the west side, (2) the east side, or (3) the center of the compound. Each group addressed traffic flow, parking, and moving the gate. The larger group determined that keeping the gate in the center of the compound would likely be the most cost effective option. However, moving the gate to the west may also be considered.

Charrette Notes

The charrette generated the following notes and comments:

- The lot was originally designed to use up the entire space available, which exceeds the design requirement. A previous contractor design included 125 spaces, even though the need is for about 60 spaces. (The maximum class size in Building 2-2332 is 49.) The surrounding lots could be used for overflow, but the lots are currently inside the security fence, they are not accessible to POVs.
- The lot will be accessible from the road (and from the building and lot visible from the road). The building and lot area are currently inside the security fence; only government and PWBC employee vehicles are allowed. The security fence in front of the building will be moved behind the building so that students attending training classes can access the parking lot.

- The lot itself will only have POVs/government cars on it. The entry into the compound (from the road back to the other PWBC lots) will have heavy equipment.
- The lot will *only* be used by classroom building occupants.
- The installation does not remove snow. Classes would be cancelled in the event of appreciable snow accumulation.
- There is some existing concrete and brick on-site that will have to be removed. If possible, these materials should be reused in the new project.
- There is currently no landscaping around the building. Soil under the sidewalks near the door of the building is already starting to erode.
- The soil is sandy with some clay. A soil borings report is available from the PWBC.
- Solar lighting should be considered for the parking lot and for the exterior public space.
- The stormwater system from the adjacent areas is at maximum. The classroom parking lot should not contribute stormwater to that system at all.
- Installation personnel have expressed a desire to keep the existing sidewalk that runs down Butner road (in front, near the road).
- Security requirements will not allow the placement of bushes/trees, etc., near the compound fence.
- A bike rack should be located in front of the classroom.
- Public transportation does not currently go to the classroom.

3 Sustainable Design Strategies

The goal of sustainable design is to meet project design objectives by using a minimum amount of resources and by imposing the minimum possible impact on the environment (both locally and globally). For this project, sustainability refers to material use, stormwater management, pollution loads, energy loads, maintenance costs and natural resource preservation/protection. Taken together this "green" parking area should employ techniques that:

- set maximums for the number of parking lots created
- minimize the dimensions of parking lot spaces
- use alternative paving surfaces
- use bioretention areas to manage and treat stormwater
- encourage shared parking and maximum use of existing pavement
- shade buildings and hard surfaces.

The Sustainable Project Rating Tool ("SPiRiT"), which was mandated for use by all Army construction projects and major renovations on 1 May 2001, was designed to help projects such as this meet sustainable design objectives. ETL 1110-3-491 Engineering and Design, Sustainable Design for Military Facilities mandates that each project earn a minimum of a Bronze SPiRiT rating. Since this project consists of a parking lot addition to an existing building, not all the SPiRiT requirements apply. The discussion below refers to SPiRiT credits when they are applicable. Appendix B summarizes SPiRiT requirements and credits that apply to the project. The SPiRiT facility points summary indicates which credits could be earned "ideally" without respect to budget constraints, and which credits might be more "realistically" earned by the project. SPiRiT and related references are accessible through URL:

http://www.cecer.army.mil/SustDesign/SPiRit.cfm

Material Use

Pavement Minimization (Related SPiRiT Credit: 1.C4.4)

An important consideration for sustainable parking lot design is to minimize the number of necessary parking spaces. Sizing lots precisely or to the average or minimum use rather than to the maximum use results in less hard surface area

and sets up the possibility of creating overflow parking on grass or other pervious surfaces. In addition, the use of underused existing surfaces also reduces the need for new parking areas. Finally, reducing the parking bay size from standard guidelines reduces the amount of paving material and construction cost while accommodating parking needs. Table 1 lists parking lot ratios for various land uses and points to the usefulness of sizing lots to average demand rather than maximum demand.

Onsite Material Reuse (Related SPiRiT Credit: 4.C2.1 and 4.C4.1)

Existing concrete and brick, where it exists, can be removed from a site before construction of the new lot. These materials can be reused if possible. Other alternatives include transporting the removed concrete and brick to a central location so it can be crushed for future use. Careful attention must be given to the quality of the recycled material to ensure it conforms to construction and pollution prevention standards.

Local Material Use (Related SPiRiT Credit 4.C5.1 and 4.C5.2)

Consideration should be given toward using gravel from demolition of other nearby projects, topsoil and mulch from a central stockpile, and local plant materials and recycled plastic lumber if available.

Stormwater Management

Pervious Surfaces (Related SPiRiT Credits 1.R1.1, 1.C6.1 and 1.C6.2)

Impervious surfaces, such as parking lots and rooftops, cause more stormwater runoff and pollutant loads than any other type of land use. These hard surfaces, which often replace vegetative cover, increase both the volume and peak rate of runoff and also provide a place for traffic-generated residues and airborne pollutants to accumulate and become available to runoff.

Table 1. Conventional minimum parking ratios (ITE 1987, Smith 1984, and Wells 1994).

Land Use	Parking Requirement		Actual Avg. Parking Demand
	Parking Ratio	Typical Range	
Single family homes	2 spaces per dwelling unit	1.5 – 2.5	1.11 spaces per unit
Shopping center	5 spaces per 1000 sq ft. GFA	4.0 – 6.5	3.97 per 1000 sq ft. GFA
Convenience store	3.3 spaces per 1000 sq ft. GFA	2.0 – 10.0	———
Industrial	1 space per 1000 sq ft. GFA	0.5 – 2.0	1.48 per 1000 sq ft. GFA
Medical/dental office	5.7 spaces per 1000 sq ft. GFA	4.5 – 10.0	4.11 per 1000 sq ft. GFA
GFA = Gross floor area of a building without storage or utility spaces			

Additionally, flooding increases during wet years and base flow decreases during dry years by reducing infiltration and soil storage while increasing evapotranspiration. Minor changes in the amount of impervious surface can have an impact on downstream rivers, lakes, and estuaries.

Stormwater management has traditionally focused on moving the quantity of runoff off-site as quickly as possible or using end-of-pipe treatment with structural best management practices such as ponds, infiltration basins, and sand filters with the focus on reducing peak flow. Sustainable development builds on these concepts by trying to retain and use a valuable runoff resource on-site while reducing storm volume impact. Techniques such as minimizing imperviousness, conserving ecosystems, increasing infiltration, reducing use of pipe and increasing natural channels, while storing runoff temporarily on-site allow a decrease in downstream nonpoint-source pollution.

Porous pavement is a permeable pavement surface with an underlying sand/stone base that provides support and temporarily stores surface runoff before infiltrating into the subsoil. Porous surfaces replace traditional pavements and allow runoff to infiltrate directly into the soil rather than to concentrate in stormwater systems. Porous pavements are natural water filters. Porous pavements composed of grass are cooler, have less glare, and are more visually pleasing than asphalt, concrete, or gravel surfaces. Effectiveness of porous paving for groundwater recharge is typically quite high, but is dependant on soil and site conditions. Effectiveness in pollutant reduction may be quite high as well, but varies depending on techniques used. Table 2, from the Stormwater Managers Resource Center, lists some data for typical stormwater pollutants (Winer 2000).

Several porous pavement options include: porous asphalt and concrete, brick or stone pavers, natural materials such as gravel and mulch, and structural turf. These surfaces can replace conventional asphalt or concrete in parking lots and driveways, but may be limited in their application due to traffic volume and type and to site conditions. The ideal application of porous pavement is in low traffic areas or portions of parking lots such as parking bays and overflow areas.

Table 2. Pollutant removal of porous pavement (%).

Pollutant	Pollutant Removal (%)*
Total suspended solids	95
Total phosphorus	65
Total nitrogen	82
NOx	NA
Metals	98-99
Bacteria	NA
* Data based on fewer than five data points	

There may be an application for porous asphalt in highways as a surface to reduce hydroplaning (SWRC 2002, Anderson 1998). Land uses or activities that generate highly contaminated runoff should not use porous pavements since the infiltration has the potential to contaminate groundwater.

Site constraints for porous pavement should meet the following criteria for proper operation:

- Soil permeability should between 0.5 and 3.0 in./hr.
- The bottom of the stone reservoir should be completely flat for maximum infiltration.
- Porous pavement should be located at least 2 to 5 ft above the seasonally high groundwater table and at least 100 ft from drinking water wells.
- Porous pavement should be located on areas not expected to be sanded during wintertime conditions.

The following discussion of porous pavement, from the Stormwater Manager's Resource Center (Appendix C), addresses features for porous asphalt and concrete. Typical features of porous pavement practices include pretreatment (the surface course), treatment (filter layer and stone reservoir), conveyance, maintenance reduction, and landscaping. In most porous pavement designs, the surface acts as a pretreatment to a stone reservoir below. Since the surface provides this service, some level of maintenance is required of the surface to prevent clogging. This is especially true of porous asphalt/concrete, but less necessary of grassed surfaces. The effectiveness of surface layers as pretreatment can be marginal, so frequent vacuum sweeping may be necessary to keep the surface clean.

The stone reservoir below the pavement surface should be composed of layers of small stone directly below the pavement surface. The stone bed below the permeable surface should be sized to attenuate storm flows for the storm event to be treated. Porous pavement is typically sized to treat a small event, such as the water quality storm (i.e., the storm that will be treated for pollutant removal), which can range from 0.5 to 1.5 in. As is the case with infiltration trenches, water can only be stored in the void spaces of the stone reservoir. For more information on the concept of infiltration trenches, see URL:

http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Infiltration%20Trench.htm

Water is conveyed to the stone reservoir through the surface of the pavement, and infiltrates into the ground through the bottom of this stone reservoir. A geosynthetic liner and sand layer should be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. Designs also need

some method to convey larger storms to the storm drain system. One option is to set storm drain inlets slightly above the surface elevation of the pavement. This allows temporary ponding above the surface if the surface clogs, but bypasses larger flows too large to be treated by the system. Other options, such as for structural turf allow for drain tile below the stone reservoir to carry off water to bioswales, detention ponds and fields, or to traditional stormwater systems.

One nonstructural component that can help ensure proper maintenance of porous pavement is the use of a carefully worded maintenance agreement that provides specific guidance on the parking lot, including how to conduct routine maintenance, and how the surface should be repaved (Table 3). Ideally, signs should be posted on the site identifying porous pavement areas. The most important landscaping objective for porous pavements is to ensure that its drainage area is fully stabilized, preventing sediment loads from clogging the pavement.

Porous asphalt (Figure 1) and concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Porous pavement of this type reduces runoff, eliminates puddling, improves wet pavement skid resistance, and may eliminate the need for curbs and storm inlets.

However, these surfaces are prone to binding especially in areas with lots of fine particles (sand) and require special maintenance. Application of porous asphalt in cold regions may suffer from freeze-thaw heaving and be quicker to freeze and slower to thaw in cold conditions. Salting is ineffective for freeze control and may actually lower ground water quality, and sand application for icy conditions will clog the surface. This is also true for high traffic applications where the potential for clogging is higher.

Paving blocks (Figure 2) are cement or plastic grids that have open areas designed to allow grass to grow within the void areas. Paving blocks make the surface more rigid and the gravel or grass planted in the spaces allow for infiltration. Depending on the use and soil types, a gravel layer can be added underneath to prevent settling and allow better infiltration. Dry-laid brick and concrete paver applications (no mortar) have great durability; replacement of damaged pieces and sections is easy. However, grass joint pavers do not hold up nearly as well. Such pavers are susceptible to frost heave and uneven settling.

Table 3. Typical maintenance activities for porous pavement.

Activity	Schedule
Avoid sealing or repaving with non-porous materials.	NA
Ensure that paving area is clean. Ensure that paving dewaters between storms. Ensure that the area is clean of sediments.	Monthly
Mow upland adjacent areas, and seed bare areas. Vacuum sweep frequently to keep surface free of sediment. Inspect the surface for deterioration.	As needed

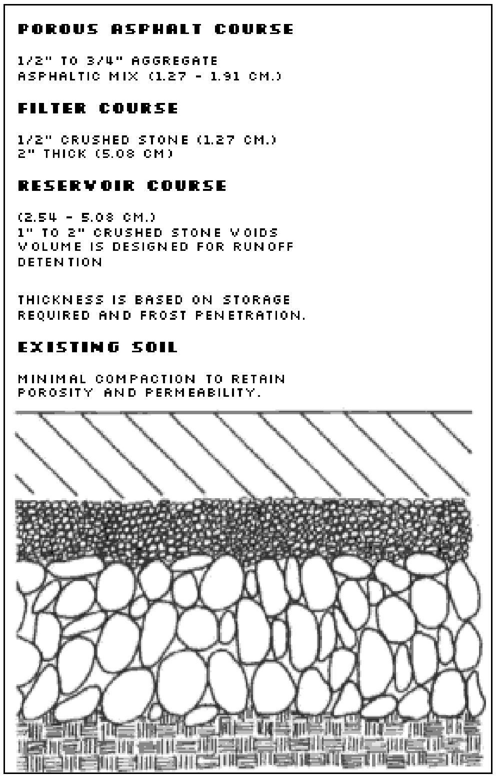

Figure 1. Schematic of porous asphalt.

Figure 2. - Grass paving blocks (structural turf in background).

Structural turf systems are the newer form of porous paving. These systems use have turf systems based in sand or sand/peat mixtures over subcourses of sand and/or stone. These structural turf systems incorporate synthetic materials into the growing medium to add structural strength and durability. A grid cell mat at the surface can be filled with grass or gravel, or a reinforcement mesh can be placed within the growth medium of the turf that greatly enhances the durability and strength of the turf to loads from vehicles, including construction and emergency equipment. These methods can be combined for better protection to the grass blades in high traffic areas such as parking lot drive lanes (Figures 3 and 4).

Figure 3. Netlon™ turf sports lot.

Figure 4. Netlon™ advanced turf.

Figure 5. Netlon™ Flexipave with lane stripe.

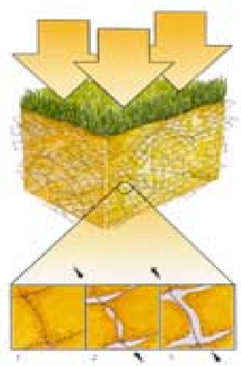

Figure 6. Netlon™ turf.

Figure 7. GrassPave™ turf.

Stormwater is filtered and cleaned as it drains through structural turf to the stone reservoir below. These turf systems provide an aesthetic stormwater inlet and help to reduce the load on existing stormwater systems. They are effective at filtering out suspended solids and provide some benefit in cleaning up other stormwater pollutants. They provide a cool surface for parking lots and reduce the temperature of stormwater passing through the system. This is important for maintaining cool stream water temperatures for temperature sensitive species such as trout.

Structural turf systems are designed to support the turf on the surface and provide structural integrity for vehicle parking (Figures 5 to 7). They necessarily have to drain well to avoid ponding problems. Ponding problems do not cause failure of the turf for parking, but do make pedestrian movement a nuisance. When built over silty loam or clay soils, drain tiles below the stone course are needed to drain the turf. Well draining soils may not need drain tiles to keep the

surface drained. Soil boring analysis would be required to design the system to a particular site.

Irrigation of turf in drought periods may be accomplished at the surface with sprinklers from traditional sources or from water storage devices such as cisterns and below grade water storage cells, or irrigated from below from various water supplies. Below-grade irrigation typically requires less than half the amount of water, produces superior plant growth, and can allow sub-surface fertilization that avoids human exposure. Structural turf systems are more expensive than asphalt or concrete to install, but provide benefits in stormwater management, water quality, parking temperatures, and aesthetics.

The Stormwater Manager Resource Center provides summary tables (below) that can be used to compare various porous pavement systems. Table 4 lists effectiveness comparisons (BASMAA 1998) and Table 5 lists installation and maintenance costs (BASMAA 1997).

Cisterns (Related SPiRiT Credit 2.C1.1 and 2.C2.2)

A cistern is a tank or storage container (usually underground) used for storing rainwater collected from a roof or other catchment area (Figure 8). Cisterns are usually used to supplement other water sources, but are especially useful for irrigation and other landscape watering (Figure 9). Aboveground cisterns may conflict with Force Protection guidelines.

Cisterns should be located near the catchment area. Underground cisterns should be located where the surrounding area can be graded and sloped away from the cistern to prevent possible contamination from surface water.

Table 4. Water quality effectiveness.

Material	Water Quality Effectiveness
Conventional asphalt/concrete	Low
Brick (in loose configuration)	Medium
Natural stone	Medium
Gravel	High
Wood mulch	High
Cobbles	Medium
Structural turf	High

Table 5. Installation and maintenance costs.

Material	Installation Cost	Maintenance Cost
Conventional asphalt/concrete	Medium	Low
Brick (in loose configuration)	High	Medium
Natural stone	High	Medium
Gravel	Low	Medium
Wood mulch	Low	Medium
Cobbles	Low	Medium
Structural turf	Low	Medium

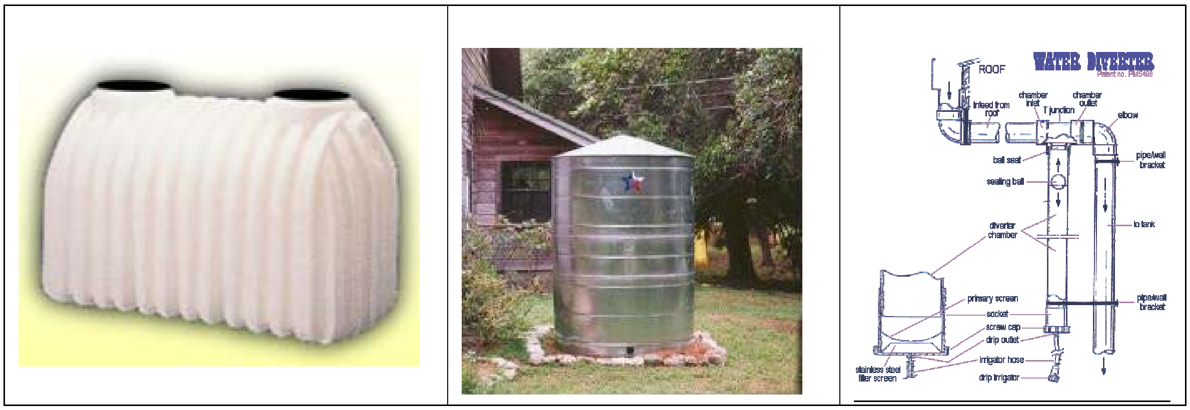

Figure 8. Underground polyethylene storage tank, above ground galvanized metal tank, and first flush rain diverter.

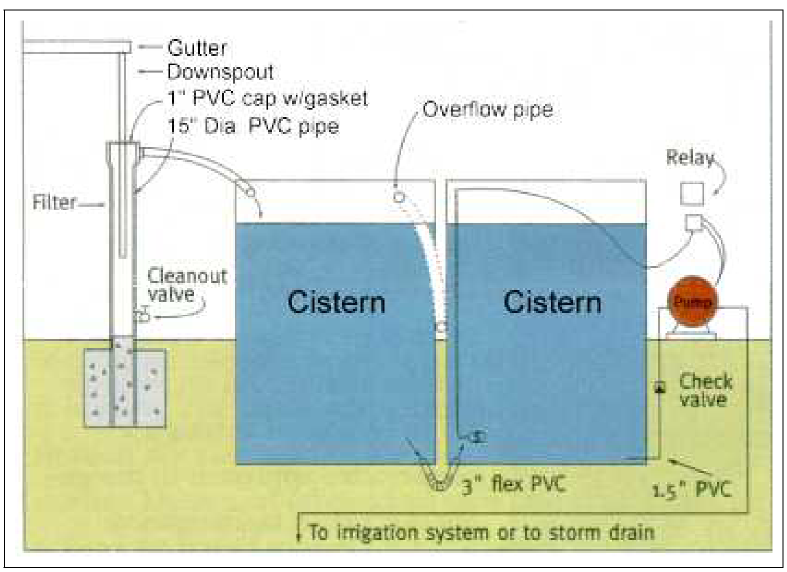

Figure 9. Typical cistern installation.

The size of the required catchment area depends on the amount of water needed and on the annual rainfall for the particular location. Building roofs are normally used for catchments. Once water needs have been determined (See SW-11, Farm and Home Water Requirements), and the rainfall data have been obtained from the weather bureau, the area of catchment can be determined from the graph shown in Figure 10. Normally, cisterns need only supply one-fourth to one-half of annual water needs (Table 6).

Water Retention Cells (Related SPiRiT Credits 2.C1.1 and 2.C2.2)

Water retention cells help to control runoff speeds, while still allowing the ground to maintain moisture at the surface for plant growth. One product, *Rainstore3*™ is a plastic structure used to store stormwater underground (Figure 11).

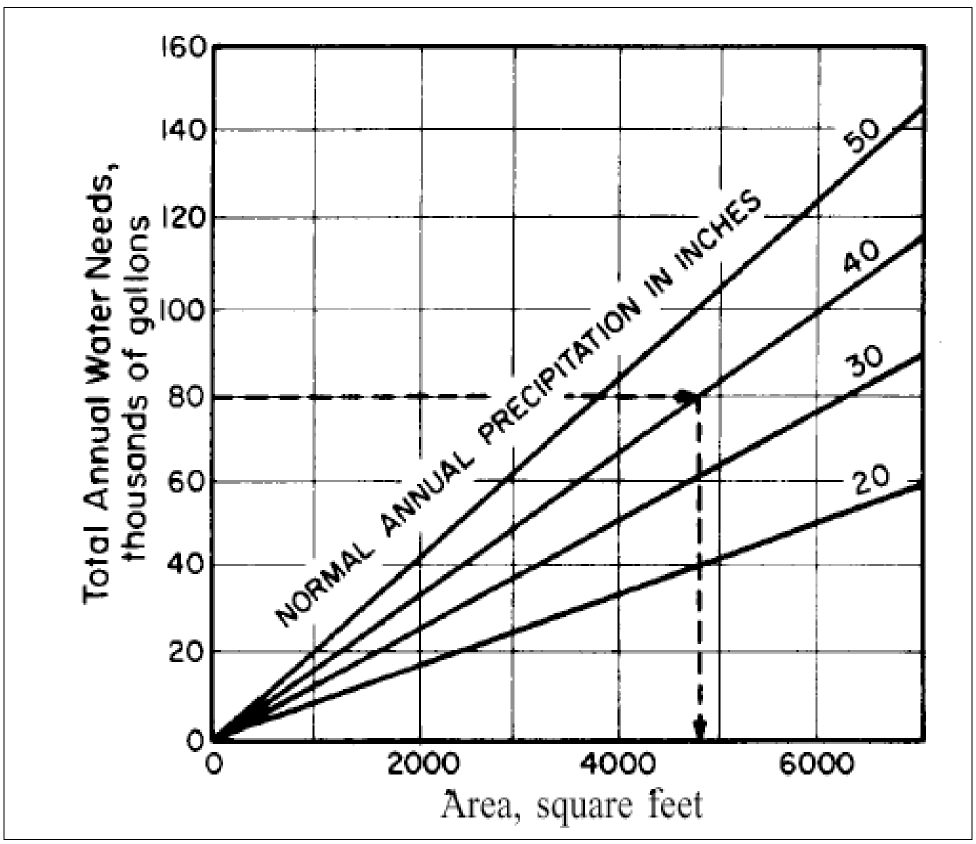

Figure 10. Cistern sizing chart.

Table 6. Water gained from catchment areas.

Water gained (gal)*	Amount of Rainfall (Inches)						
	1.0	2.0	3.0	4.0	5.0	6.0	7.0
500	1200	600	400	300	250	200	200
1000	2400	1200	800	600	500	400	350
1500	3600	1800	1200	900	750	600	500
2000	4800	2400	1600	1200	1000	800	700
2500	6000	3000	2000	1500	1200	1000	850
3000	7200	3600	2400	1800	1450	1200	1000

* Assumes a loss of 1/3 from wind, leakage, and evaporation.

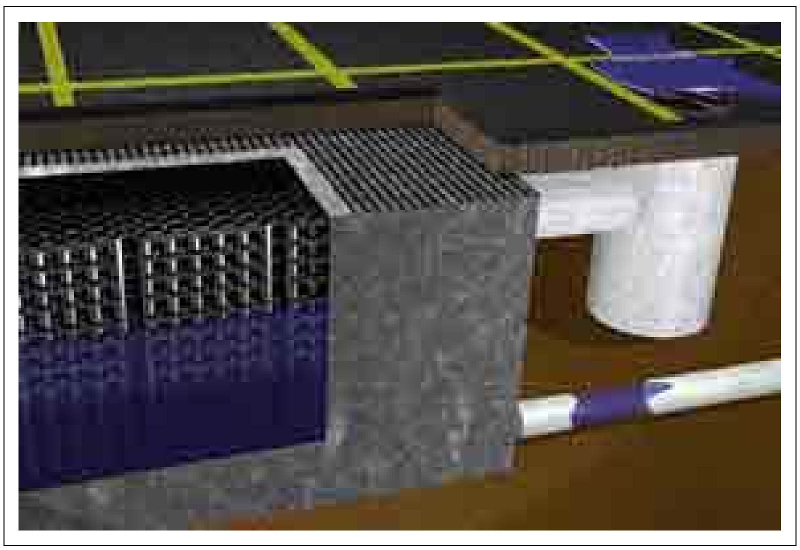

Figure 11. RainStore™ water storage cell shown below parking lot.

Made from injection molded plastic, a single panel contains 36 vertical columns and supports H-20 loading, allowing the construction of driving areas, parking lots, or other small structures above the system. Built-in compression fittings allow units to be easily stacked to a variety of depths up to 8 ft, 4 in. Some benefits are that the system:

- allows development of valuable land resources by moving stormwater ponds below ground
- is available pre-assembled in depths from 4 ft to 8 ft, 4 in.
- is 94 percent open for water storage - (250 gal/ m^3)
- virtually eliminates stone requirements
- is easy to install.

Biofiltration/Bioinfiltration Swales (Related SPiRiT Credits 1.C6.1 and 1.C6.2)

Biofiltration/bioinfiltration swales are vegetated channels with a slope similar to that of standard storm drains channels (less than 6 percent), but wider and shallower to maximize flow residence time and promote pollutant removal by filtration through the use of properly selected vegetation and settling. The sites are capable of removing pollutants through a variety of physical and biological processes along with infiltrating runoff into the groundwater. While pollutant removal rates have yet to be precisely measured, their capability is considered comparable to a dry swale which removes 91 percent of total suspended solids (TSS), 67 percent or better of phosphorus, 92 percent of nitrogen, and 80 to 90 percent of metals (Claytor and Schueler 1996). Bioretention areas are often designed as an off-line treatment system. Components include: grass buffer strip, ponding area, planting soil, sand bed, organic layer and plant material. Additional information is available in Stormwater Best Management Practices from the North Carolina Department of Environment and Natural Resources (NCDENR) on the web.

Similar to these is the concept of rain gardens, which also use vegetation and infiltration to treat and reduce runoff from small areas. Grass swales and filter strips are additional methods for reducing and treating runoff. Proper construction of these simple measures is important to prevent early failure. Bioretention swales vary in capacity. For example, sand can infiltrate 8 in. of water/hr while loam will exfiltrate 0.52 in./hr. North Carolina guidance suggests that 7 percent of a site landscaped with swales will treat 0.5 in. of rain effectively.

Infiltration Basins (Related SPiRiT Credits 1.C6.1 and 1.C6.2)

The soils on Fort Bragg have a large component of sand. This feature indicates the feasibility of infiltration basins, trenches, dry wells, or French drains and similar options for reducing the amount of water leaving the site. These devices allow recharge into the soils and groundwater of the area. Infiltration basins are normally dry basins with permeable soils that allow exfiltration into the ground. Infiltration trenches are ditches that fill with stormwater runoff and allow the water to exfiltrate into the soil. Some versions use large crushed stone to create voids for water storage while others use precast concrete chambers to provide a large storage volume. Infiltration trenches are usually used to handle water from parking lots and buildings. Dry wells are constructed similarly to infiltration basins, but are usually more compact and less elongated. They are most useful for receiving runoff from roofs of buildings and allowing it to exfiltrate into the soil (Figure 12).

Rain Gardens (Related SPiRiT Credits 1.C6.1 and 1.C6.2 and 2.C1.1)

The term “rain garden” refers to a shallow constructed depressional area that is used as a landscape tool to improve water quality. This bioretention area provides infiltration and water storage for sheet flow that is precipitation generated. They are commonly located in parking lot islands or within small pockets in residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff water forms ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system.

The remaining runoff filters through the mulch and prepared soil mix. Plants placed in rain gardens should be able to tolerate varying wet conditions, with some plants more wet than others. Grass and forbs (herbs other than grass) are typical as well as woody shrubs and trees. Rain gardens can be sized depending on the amount and flow of water. In small scale building applications, downspouts or cistern overflows can be diverted to the rain garden. Small-scale rain garden could allow overflow to sheet off, whereas larger systems such as for parking lots should have overflow inlets. Figure 13 shows a design for a parking lot bioretention system provided by the Stormwater Manger’s Resource Center.

Figure 12. Bioswale at the Oregon Museum of Science and Industry.

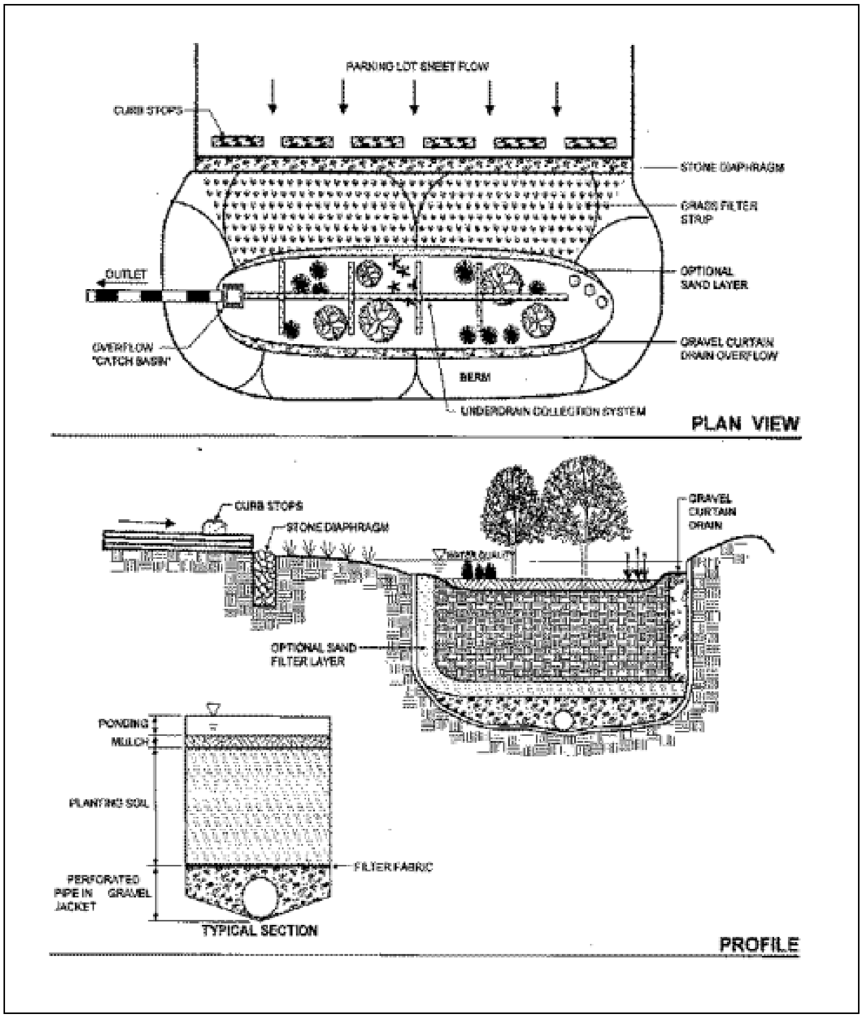

Figure 13. Bioretention schematic design for parking lots.

Pollution Loads (Related SPiRiT Credits 1.R1.1, 1.C6.1 and 1.C6.2)

Rain events can wash off and concentrate pollutants from parking lots, roadways, lawns, rooftops, and other surfaces. Controlling and treating water pollution from rain events can be accomplished through the use of filters for storm drain inlets and bioswales for overland and discharge flows. Bioswales use growing plants to filter and adsorb/absorb pollutants and, in many cases, compost as a medium for holding and breaking down water pollutants including petroleum byproducts.

Additional methods for treating water runoff from parking surfaces and roads include modified catch basins and catch basin inserts. These devices may be installed in new construction or retrofitted to existing inlet structures. Water is

treated through a combination of screens and filters for debris collection, and oil/water separators, and filter media such as activated carbon or compost for trapping and breaking down organic and inorganic pollutants.

Figures 14, 15, and 16 show catch basins and catch basin inserts from several vendors. These devices take the place of a traditional inlet structure in a storm sewer system and typically filter out hydrocarbons, organically bound metals PCBs, pesticides, VOCs, sulfides and other contaminating industrial waste products from stormwater and industrial runoff. The Inlet Stormceptor™ is a 48-in. diameter precast concrete structure with a fiberglass insert. The insert extends into the treatment chamber, providing dual wall containment of hydrocarbons.

Figure 14. Flo-Gard™ catch basin insert.

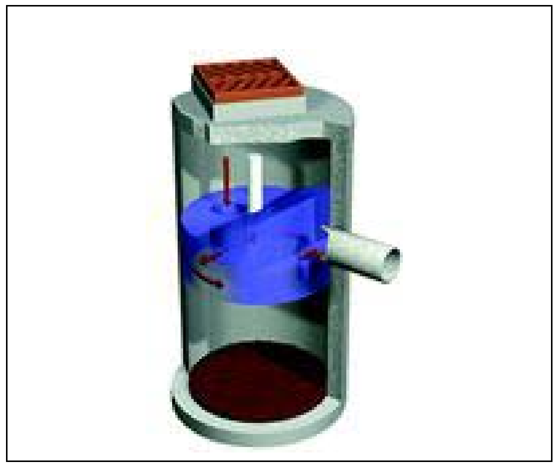

Figure 15. Inlet Stormceptor™ Catch Basin.

Under normal operating conditions (more than 90 percent of all storm events), stormwater flows into the upper chamber and is diverted by a sloped weir into the lower chamber. Flow is diverted by horizontal outlets around the walls of the lower chamber, settling out coarse and fine sediments to the floor of the chamber. Petroleum products rise and become trapped beneath the fiberglass insert.

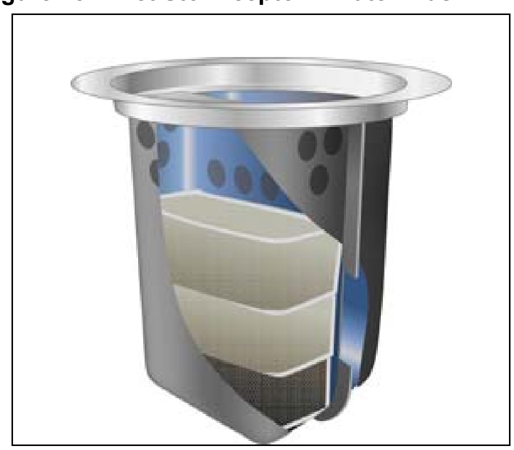

Figure 16. Hydro-Kleen™ basin insert.

The catch basin devices are good at trapping and holding total suspended solids (TSS) and oil, but regular maintenance is required as they may fill quickly with sediment and oil. Maintenance schedules will vary according to the load they experience.

Energy Loads

Lighting (Related SPiRiT Credits 1.C8.1 and 3.C2.1)

Lighting for the parking lots can be provided by photovoltaic, battery-powered streetlights. These units are available from a number of manufacturers and have the same lighting characteristics as standard outdoor parking lot lighting. The initial cost per lamp is higher than traditional lights, but there is less installation cost (no trenching, wiring, or meters to install) and there are no operation costs. (Even the gel batteries are maintenance free.) In addition, solar-powered lights provide a dependability of operation during power outages that wired lights cannot provide. Typical solar lights (Figures 17, 18, and 19) recharge batteries even under cloudy days and can power lamps for up to 5 days without sunlight. They can be mounted on a pole or on walls and use commercial lighting fluorescent bulbs for long life. Another option is the hybrid wind and Photovoltaic light made by MoonCell. The MoonCell light uses LED bulbs, which are quite compatible with the amount of electricity generated by the photovoltaic cells on the top of the light. The wind turbine suspended below the lamp will provide extra electricity on shady days.

Figure 17. Solar parking lot lights.

Figure 18. Solar parking lot light.

Shading (Related SPiRiT Credits 1.C7.1)

Especially in warm climates, unshaded parking lots become extremely hot, contributing to both the urban heat island effect and increased air pollution through enhanced volatilization of reactive hydrocarbons from parked vehicles. Surface temperatures of the parking mass and surrounding buildings can be reduced with proper shading strategies. Hence, many communities require that newly constructed or reconstructed parking lots be shaded through the incorporation of tree plantings into the parking lot design. Requirements for tree planting in parking lots are sometimes enacted though a specific parking lot shading ordinance, but the code may be incorporated into the city code related to trees, landscaping, parking lots, or elsewhere.

Figure 19. Solar-powered light.

Typical goals for shading hard surfaces such as parking lots specify that 50 percent of the surface be in shade, either from trees, carports, or arbor structures within 15 years of development of the lot. Shading for buildings can be accomplished with tree canopy, foundation shrubs, or with vines on the building walls or trellis structures. However, military applications do not allow plant material to block visibility to the structure within the standoff distance.

Maintenance Costs (Related SPiRiT Credit 7.C1.2)

Pavement sealing and parking bay restriping are not required for nonasphalt areas. Parking bay lanes for structural turf areas are marked permanently by filling the porous paving grid cells with fine gravel rather than turf. Porous pavers such as EcoStone® may be striped by using a course of contrasting color in place of applied paint. Structural turf requires normal mowing and fertilization routines (humates or other organic fertilizers). Humates are organic fertilizers derived from mined carbon called "Leonardite" and are available commercially

Porous pavement such as porous asphalt and EcoStone® pavers require regular sweeping and vacuuming to maintain their ability to infiltrate water. Maintenance will vary depending on the amount and type of debris that collects. Leaf, twig, and soil debris account for much of the clogging associated with EcoStone®.

Porous asphalt may be clogged with organic debris and with sand and silt. Asphalt areas that abut structural turf should be slightly higher than turf to allow for snow removal without damage to the turf. Portions of structural turf may exhibit poor plant growth at times and would require supplemental irrigation and/or fertilization. This often results from the fact that the turf is growing in a shallow root medium (for some structural turf products) over stone.

Snow removal on structural turf and grass paver blocks area may be problematic. Paver blocks such as Grasscrete™ may settle differentially or shift over time to create a somewhat uneven surface. For this reason, snow plows should be set for at least 1 in. above the surface to prevent turf gouging and hitting pavers that may have shifted.

Natural Resources Protection/Preservation (Related SPiRiT Credits 1.C11.1 and 2.C1.1)

Native and adapted species should be used to reduce water and maintenance requirements. Native species are suited to the soil and moisture conditions of their range and are prepare for drought conditions. In the sandhills landscape, the dominant plant community is the Longleaf Pine-wire grass community. Longleaf pine and turkey oak are the dominant overstory plants. Other plants, found in moister bottomlands, such as white and red oaks, yellow poplar, maples, persimmon, holly, dogwood, and sourwood would also be a logical choice for this project site. Finally, plants found in open meadow areas including flowering forbs and shrubs such as holly and rhododendrons are good choices.

Areas not paved should consider use of native and adapted plants as cover and as an outdoor classroom. Grasses, forbs, and woody plants appropriate for bioswales should be used. This will ensure proper function of the bioswale while reducing plant replacement and maintenance. Shrubs (except open crown shrubs such as serviceberry) and low canopy trees such as white cedar and juniper cannot be used adjacent to buildings as per Force Protection Guidelines. A suggested plant list is contained in Appendix D. Additional listing is available from the North Carolina's Stormwater Best Management Practices publication.

4 Parking Lot Schematic Designs

This chapter discusses the design considerations for the Fort Bragg classroom parking lot and their application in the form of four alternative solutions. Each solution is reviewed in terms of spatial layout, pavement efficiency, circulation patterns, gate design, placement of outdoor classroom, size and placement of natural areas and bioswales, and views. The advantages and disadvantages of each design alternative is presented for easy comparison.

The Sustainable Project Rating Tool (SPiRiT v. 1.4.1), developed by the U.S. Army Corps of Engineers for the Assistant Chief of Staff for Installation Management (ETL 1110-3-491 Engineering and Design [01 May 2001]), was used in this project as a guide for sustainability practices for construction projects. SPiRiT is a rating tool that offers a checklist, strategies, and scores for sustainable facilities and as such, it allows environmentally responsible practices to be integrated into the process of facility delivery. The reader is urged to review a copy of the tool for reference purposes. Application of the SPiRiT tool to this project is explained in Chapter 5.

Schematic Design Considerations

Parking Requirements

- *Vehicle* – to be 60 spaces, including two handicapped. Standard 9 ft x 18 ft bays.
- *Bicycle* – a bike rack will be provided as per SPiRiT guidelines.
- *Motorcycle* – motorcycle parking will be installed near the bicycle rack.

Force Protection

The 30-ft standoff distance from the classroom building and nearby brick building will be carefully maintained. 25 ft from Butner Road will be maintained as well. Plant material within the standoff distance of the classroom building will consist of trees, 1 to 3 stem shrubs that are pruned up, and groundcovers. These plant types conform to force protection guidelines by maintaining visibility to the building.

Aesthetics

A parking lot is difficult to design for both aesthetics *and* efficiency. A solution to this would be to provide lush vegetation to create a park-like feel, while breaking up the monotony of a flat, graded area. The main limitation to landscaping will be the Force Protection guidelines.

Outdoor Break Area/Seating Area

An area will be set aside adjacent to the classroom building to act as a refuge for students and teachers. This area will be equipped with recycled plastic lumber benches, tables, and lush greenery.

Circulation

Most of the movement around Fort Bragg is accomplished via automobiles. Semis will be accommodated at the entrance to the PWBC compound. For this reason, the main entrances are designed around the flow of cars and trucks. Pedestrian and bicycle traffic is managed through the use of sidewalks and crosswalks.

Views

Taking into account the Force Protection guidelines, the vegetation around the parking lot will allow all required viewability. Trees will be sited in such a way as to not block the views of drivers, and will be limbed-up to allow for views to/from the street.

PWBC Compound Entrance

The entrance will be designed to accommodate large vehicles and to provide a pleasant, architectural statement of Fort Bragg's history within the Army and the Corps of Engineers.

Security Fence

A standard security fence will be provided between the parking lot and the PWBC compound. This fence will also be behind the classroom building, as it is designed for public accessibility.

Bus Access

Whether or not a bus route through the parking lot is needed is still under speculation. CERL has provided some schemes that could employ a bus path.

Total Water Budget

- Design storm: 24 hr, 25 yr, produces 6.7 in. of rain
- Hydrologic soil group: most likely Group B or C according to the site soil borings.
- Curve number: estimating 75 percent hardstand, 25 percent meadow equals 81 for B soils, 87 for C soils
- Runoff depth from SCS table – 4.6 in. for B soils, 5.2 in. for C soils.
- The drainage area of the site is approximately 200 by 350 ft = 70,000 feet square, about 1.6 acres
- The on-site building is 68 ft by 53 ft = 3600 sq ft This area is also included in the total site drainage.
- Runoff volume = 4.6 in. x 70,000 ft sq = 26833 cu ft (about 200,700 gal) for total site for B soils. For C soils, potential runoff is 5.2 in. x 70,000 ft sq or 30,333 cu ft (about 226,900 gal).
- From the building, the first 0.1-in. produces about 225 gal. This is the dirtiest portion of runoff containing dust, airborne pollutants, bird droppings, etc., and should be directed onto the ground through a drainpipe. After that, each inch of rain will capture about 2250 gal; this clean water can be captured in cisterns for reuse for toilet flushing or irrigation. (This water is high quality, and in fact, is often used for drinking water in many other nations.)
- If the total rainfall for the design storm landed on the roof, that would total 2010 cubic ft or 15,000 gal of runoff. After filling any cisterns, the excess should be passed into a dry well or infiltration basin.
- To control the remainder of runoff coming off the site, use combinations of infiltration basins, underground storage, bioretention swales with check dams, dry detention basins, grasspave, etc. to infiltrate and temporarily store water on site. The sum of these total components will minimize runoff leaving the site and stressing the installation stormwater system.

Solutions

The ideas contained in the following schematic designs can be applied effectively to many lot layouts. It is assumed that all parking lot designs will use recycled concrete pavement (existing concrete can be used as aggregate) for the driving surfaces, while employing porous pavement for the parking spots themselves.

Plant types, listed in Appendix D, and solar lighting are also applicable to all designs. Additionally, all schemes use cisterns for roof runoff storage, and underground cells for runoff control. Placement of the parking lot will affect the location of underground storage, the bioswale, and porous pavement, however, the concepts remain the same.

General Design Notes (Applicable to All Schemes)

Chain Link Fence

A new PWBC entrance gate in each design is shown about 100 ft in from Butner Road. It consists if a double swing gate entry/exit traffic separated by a median. Realignment of the compound fence should proceed from the entry gate and surround the classroom building along its north elevation and connect to the existing fence at the east end of the project limits.

Parking Lot Construction and Drainage

The parking lot shall be 60 spaces with two spaces in Americans with Disabilities Act (ADA) compliance. The drive lanes shall consist of asphalt or recycled concrete with the bays in porous pavement to allow for stormwater infiltration. The lot shall be crowned in the center of the drive and allow for drainage to the bays, center bioswales, or lot edge. No curbing shall exist except along the curves of the entrance/exit drives from Butner Road. Parking bays shall use concrete or recycled plastic vehicle stops. Striping can be either stone-filled cells (such as in structural turf cells), recessed light colored stone markers, or traditional striping on porous asphalt. Fertilization schedules of grassed porous paving shall be similar to that of sports turf and should consist of commercially available organic humates. Irrigation schedules are as needed, but may be simplified through below-ground meters such as soil moisture meters or float gauges installed in the drain tiles.

Subsurface Water Storage

Some stormwater storage can occur below the surface of the drive lane of the parking lot using recycled plastic cells. Infiltration of water through the porous parking bays or from stormwater inlets along the PWBC compound entrance drive can provide water for storage. Irrigation for lawn areas and for other plant material can come from the subsurface storage cells. Overflow of the subsurface storage goes to the bioinfiltration swale along Butner Road.

Cisterns

Four 1200-gal polyethylene tanks can be buried at the corner downspout locations of the classroom building. First flush diverters shall be used to ensure clean water is stored. Overflow shall be directed to rain gardens at the east and west sides of the buildings. Solar-powered pumps can be installed to pump off cistern water to irrigate rain gardens or other areas.

Rain Gardens

Rain gardens can be employed on the east and west sides of the classroom building to capture, filter, and hold overflow water from the cisterns. The rain gardens should be planted with 60 percent grasses and 40 percent forbs and should tolerate varying levels of soil moisture (refer to Appendix D for suggested plant list). The native grasses/forbs section of the rain garden should begin 30 ft beyond the building since this plant material height does not conform to force protection guidelines. The approaches to the rain gardens may be a combination of cistern overflow spouts and turf grass. The structural turf grass should be mowed similar to normal turf grass (actual grass height will depend on species and type of turf construction).

Shading

Shade trees shall be used along the sides of the lot to provide shade for vehicles and pavement. A combination of shade trees, shrubs, and groundcovers around the classroom building can provide shading and cool zones.

Aesthetics

A row of longleaf pine or other tree along the west edge of the project can provide a visual screen to the adjacent building. Ornamental trees and shrubs along the parking lot entrance drive and near the classroom provide visual keys and interest to the lot and building entrances. Groundcovers are used extensively around the building for visual interest and to reduce mowing requirements. Space is available on the project site for an outdoor classroom and demonstration area. Underused turf areas should be planted in native grasses and forbs (e.g., wiregrass community), as well as "woodys" to increase overland stormwater infiltration and reduce mowing requirements. Planting areas around the classroom building consist of groundcovers, and woody plants such as serviceberry shrubs and trees that allow visibility to the building.

Stormwater Management

Linked systems of stormwater capture and bioinfiltration techniques are employed on the project site. Water hitting the classroom is captured in buried cisterns at the four corners of the building. Overflow is directed to the rain gardens. It is expected that the 25-yr storm event will not exceed flows through this system. Any overflow of the rain gardens occurs as overland sheet flow to other parts of the project site where it may be captured again.

Stormwater hitting open planted areas of the site is expected to be absorbed since they are planted in native grass and forbs planted in soil amended with compost. These plant systems have deep vertical roots relative to turf grasses that allow much better water infiltration and absorption. Areas planted in turf are limited, but where occurring, they should be graded in shallow swales to help retain water until absorbed.

Stormwater hitting the parking lot is directed either to stormwater inlets, porous paving areas, or to bioswales. Some of this water is absorbed, some may be directed to a cell storage structure below the pavement, and some is directed to bioinfiltration swales. The main (and last) bioinfiltration swale is located along Butner Road between the road and the parking lot. This area is typically an area developed as a culvert to carry water where stormwater lines are not present. In this case, it acts as an infiltration basin to hold water directed to it from other areas on the site either directly through overflow piping or by overland flow. This swale is expected to hold the 25-yr, 24-hr design storm of central North Carolina. Its overflow for larger events is through a road culvert to an open field on the south side of Butner road.

Pollution Management

First flush runoff from the classroom building is directed to a downspout diverter where it traps sediment washed from the roof and gutters. Regular cleaning of the filter is expected after rain events and may be placed in the rain garden. This keeps the cistern water clean and prevents clogging of the lines. The rain gardens infiltrate stormwater and filter out debris and sediment. They are also effective in breaking down and absorbing all stormwater pollutants through the plant material shoots and roots, compost bedding, and the underlying soil.

Stormwater draining into pavement inlets go through inlet inserts that trap debris and sediment, as well as separate oil and grease from the water. Regular maintenance of these filters is needed for peak performance. The porous pave-

ment areas act as natural sediment filters and help to break down pollutants. Bioinfiltration swales filter water and break down/absorb pollutants.

Slope and run distance (the distance along a slope before it flattens out) greatly effect bioinfiltration effectiveness. Too much water moving too fast washes sediment and pollutants through the system and may actually scour the bottom and sides of the swale. Flat bottom swales with slopes less than 4 percent are required unless a check dam is placed in the swale. Inlet structures to swales should have energy dissipaters and slope and bottom erosion protection.

Scheme A

Spatial Layout

This scheme represents the maximum possible use of site in the east-west direction. This layout is very efficient, and traffic will flow smoothly through its the dual entrances (one positioned at each end of the lot). This scheme allows for a long, meandering bioswale at the south end of the lot, adjacent to Butner Road. A walking path through this area could be used to introduce pedestrians to the technology in place in a bioswale. Also, the ample space left to the west of the classroom could provide a pleasant outdoor area.

Pavement Efficiency

Pavement Efficiency, in terms of % Impervious and % Pervious is: 48.8 percent impervious, 51.2 percent pervious (10,375 sq ft pavement, 10,875 sq ft porous surface, for a total of 21,250 sq ft).

Circulation Patterns (Including Buses, Semi Trucks, and Government Vehicles)

Using two entrances for the parking lot, the classroom is autonomous of the PWBC main entrance. Buses may enter the lot, drop off passengers, and exit without entering the compound. The existing location of the PWBC entrance is preserved, and only minor changes to the curbing are made.

Gate Design

To be determined.

Placement of Outdoor Classroom

Located to the west of Building 2-2332 (Figure 20).

Size and Placement of Natural Areas and Bioswales

Natural areas are suggestions, and will be finalized through input from landscape architects at Savannah District. Bioswale sizes will need to be calculated after parking lot design is finalized and site grades are determined. This will be completed during the Design Development and Construction Documentation phases, which Savannah District will conduct.

Views

Because this scheme places the parking lot between Butner Road and Building 2-2332, trees will need to be limbed up to account for Force Protection guidelines.

Advantages/Disadvantages

Scheme A is the simplest scheme, but it is also the least aesthetically pleasing. It would be simple to grade, build, and maintain, and contains the least amount of paved area. However, its linear orientation within the limits of the site boundaries (and accounting for Force Protection guidelines) prevents the use of tree islands. If some spaces can be removed, tree islands—which would provide additional shade and greenery—could replace them (Figure 20).

Scheme B

Spatial Layout

This scheme is a variation of Scheme A. By eliminating one entrance from Butner Road (through the dual use of the main PWBC entrance) this lot can be made shorter, which allows for some expansion to the west at a later date. This scheme also provides for parking to the east of the classroom building.

Pavement Efficiency

Pavement Efficiency, in terms of % Impervious and % Pervious is: 49.8 percent impervious, 50.2 percent pervious (10,650 sq ft pavement, 10,725 sq ft porous surface, for a total of: 21,375 sq ft).

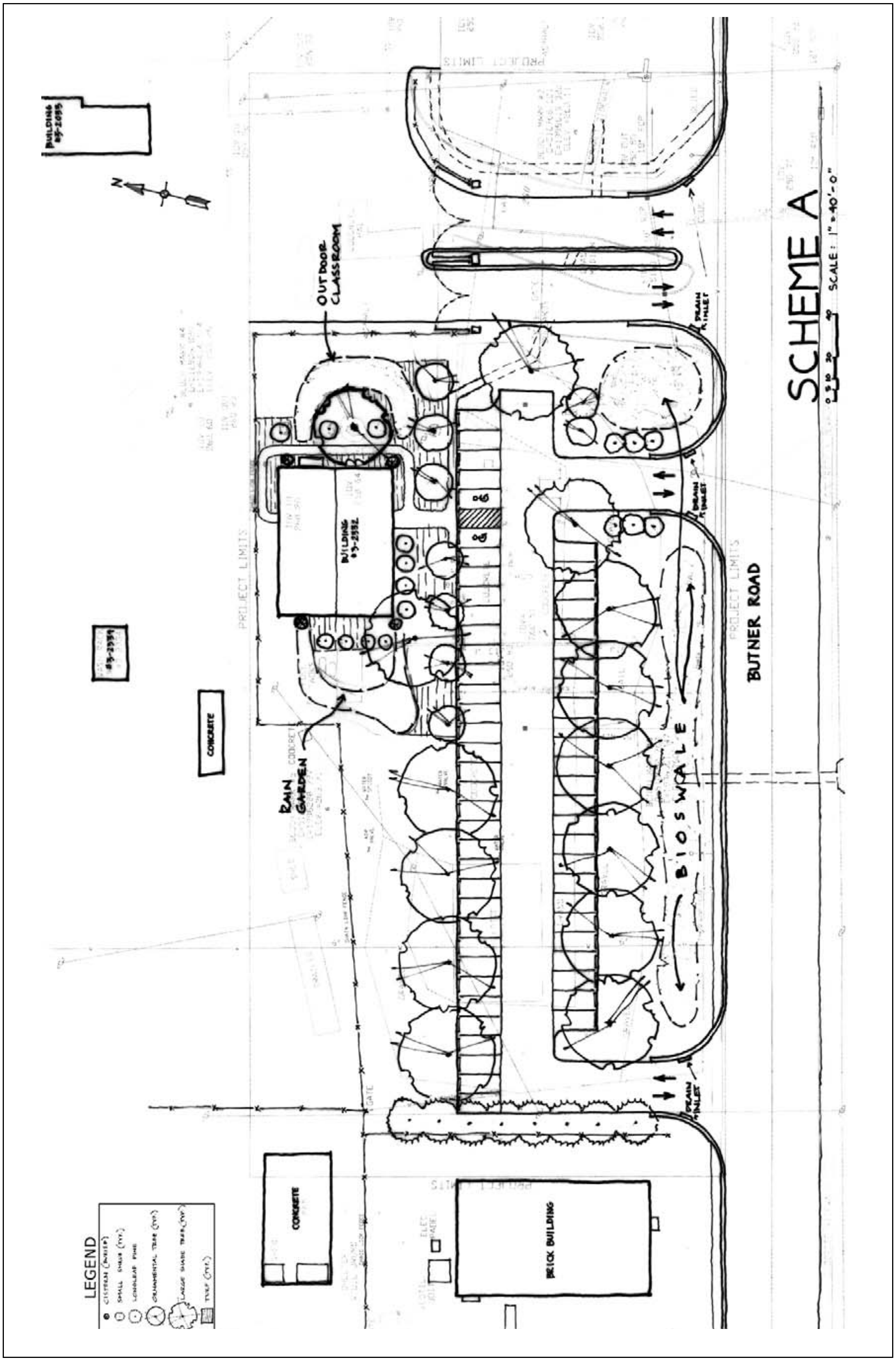

Figure 20. Scheme A — to grade, build, and maintain the least amount of paved area (not to scale).

Circulation Patterns (Including Buses, Semi Trucks, and Government Vehicles)

The main constraint to this scheme is traffic management at peak hours. For this reason, CERL has proposed the use of an automatic gate, which would prevent passage at the east entrance during the morning and evening rush hours. Buses would still be able to enter the lot, drop off passengers, and exit without entering the compound. The existing location of the PWBC entrance is the same size and shape as shown in schemes A, C, and D, but it is shifted approximately 20 ft to the east to accommodate parking spaces.

Gate Design

To be determined.

Placement of Outdoor Classroom

Located to the west of Building 2-2332 (Figure 21).

Size and Placement of Natural Areas and Bioswales

Natural areas are suggestions, and will be finalized through input from landscape architects at Savannah District. Bioswale sizes will need to be calculated after parking lot design is finalized and site grades are determined. This will be completed during the Design Development and Construction Documentation phases, which Savannah District will conduct.

Views

Because of this scheme places the parking lot between Butner Road and building 2-2332, trees will need to be limbed up to account for Force Protection guidelines.

Advantages/Disadvantages

Scheme B is the second-most efficient scheme, and is far more aesthetically pleasing than Scheme A. Additionally, the location of additional spaces in the area immediately east of Building 2-2332 gives shorter walking distances. The main disadvantage to this scheme is its dependence on the main PWBC entrance drive for its secondary access. Unless properly regulated through the use of a timed gate, this could be the cause of congestion at peak hours (Figure 21).

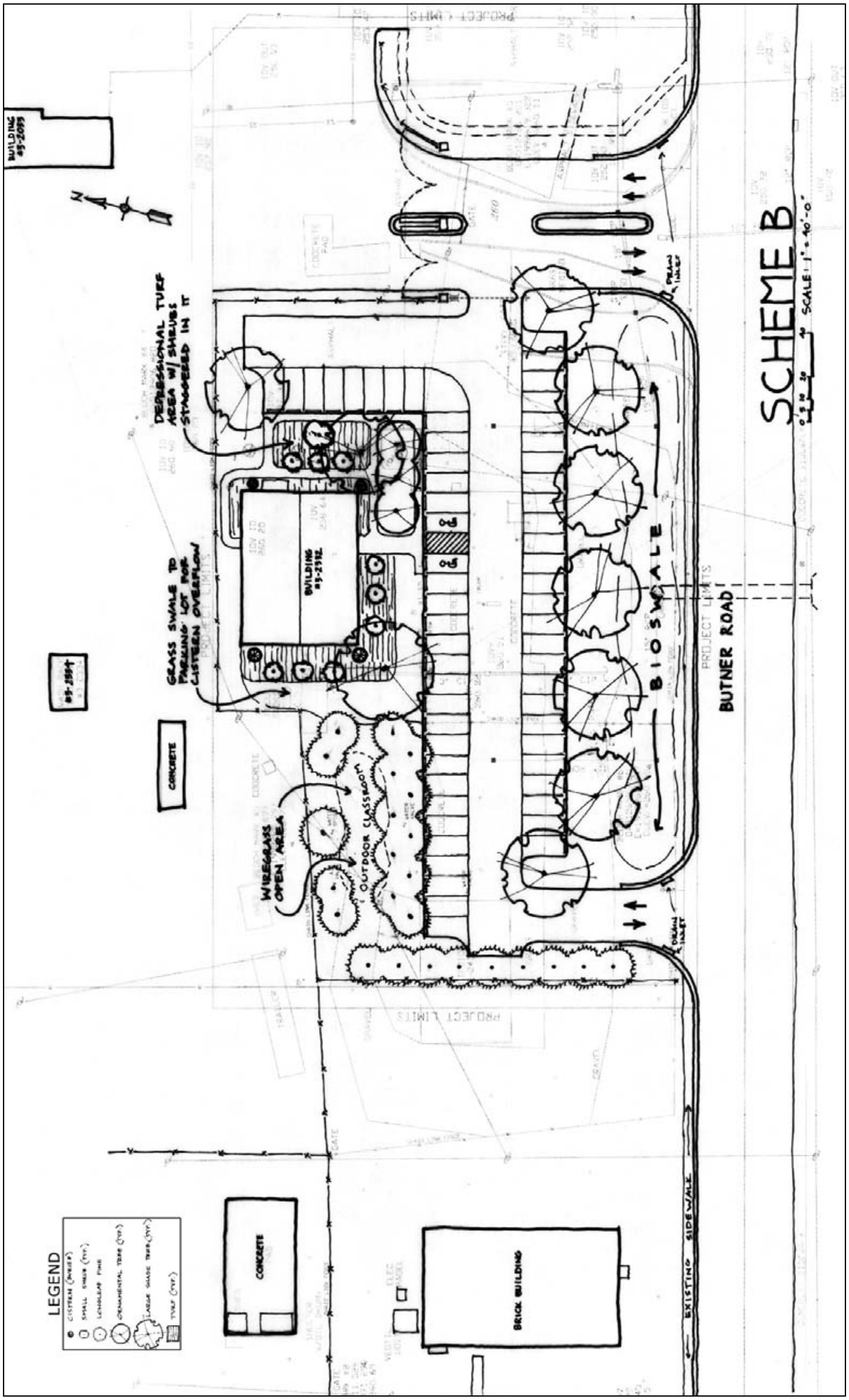

Figure 21. Scheme B (not to scale) — in which the location of additional spaces east of building 2-2332 gives shorter walking distances.

Scheme C

Spatial Layout

This scheme represents a maximized use of the space directly west of the classroom building. A lot oriented in such a fashion would provide unobstructed views between the classroom building and Butner Road, while also leaving ample green space. This scheme lends itself to the placement of the bioswale to the south of the classroom building, and an outdoor area located nearby.

Pavement Efficiency

Pavement Efficiency, in terms of % Impervious and % Pervious is: 59.6 percent impervious, 40.4 percent pervious (16,150 sq ft pavement, 10,925 sq ft porous surface, for a total of 27,075 sq ft).

Circulation Patterns (Including Buses, Semi Trucks, and Government Vehicles)

Scheme C is similar to Scheme A, in that it uses an autonomous entrance off of Butner Road. This entrance is sized such that buses would be able to enter the lot, drop off passengers, and exit without entering the compound. The existing location of the PWBC entrance is the same size and shape as shown in schemes A and D.

Gate Design

To be determined.

Placement of Outdoor Classroom

Located to the west of Building 2-2332 (Figure 22).

Size and Placement of Natural Areas and Bioswales

Natural areas are suggestions, and will be finalized through input from landscape architects at Savannah District. Bioswale sizes will need to be calculated after parking lot design is finalized and site grades are determined. This will be completed during the Design Development and Construction Documentation phases, which Savannah District will conduct.

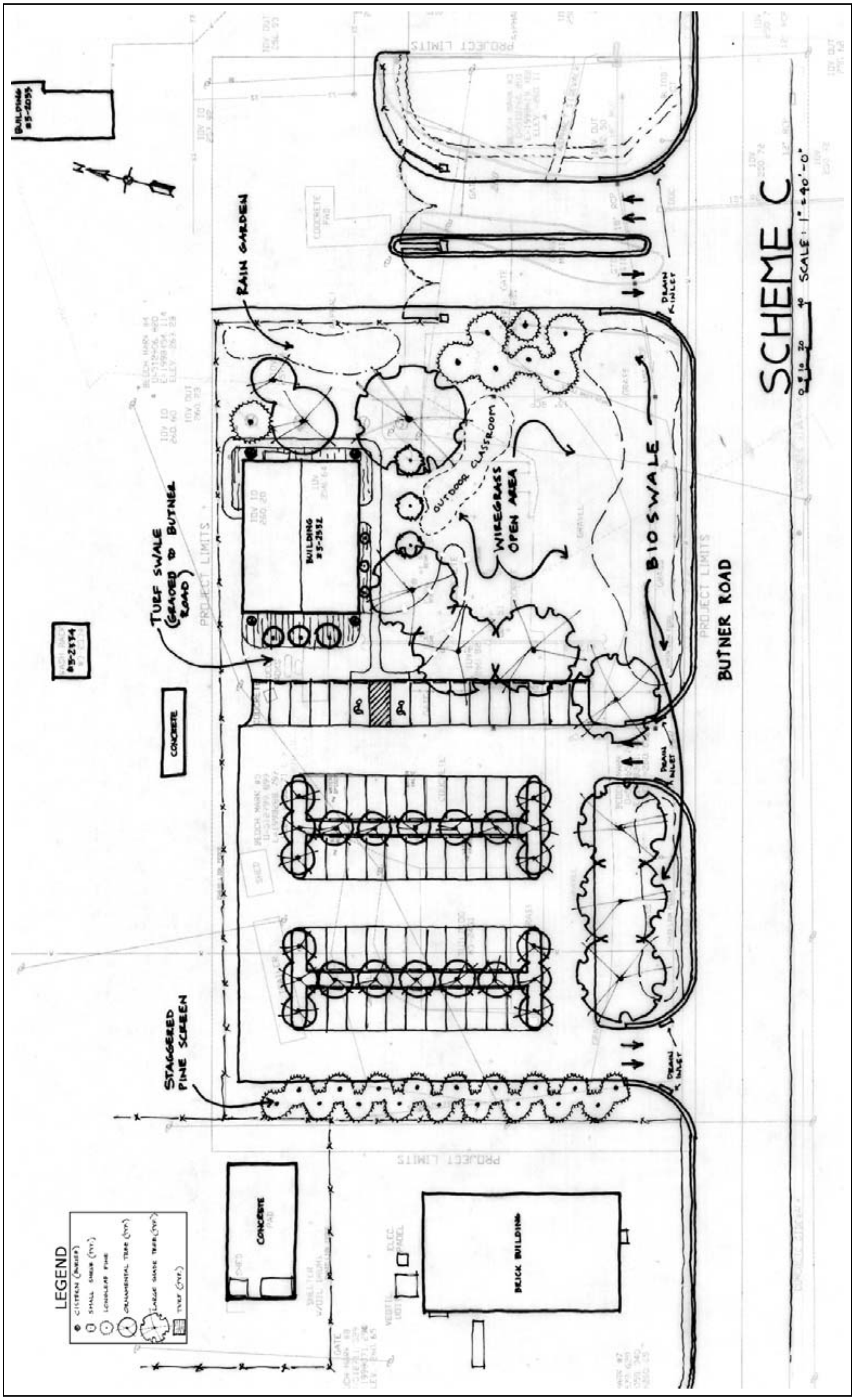

Figure 22. Scheme C (not to scale) — both aesthetically and technically pleasing, but uses significantly more pavement.

Views

By keeping most of the plantings between the classroom building and the brick building to the west, visibility to Butner Road should not be obstructed. As in other schemes, trees would need to be limbed up according to Force Protection guidelines.

Advantages/Disadvantages

Scheme C is both aesthetically and technically pleasing, but uses significantly more pavement. This scheme could be made more efficient by eliminating the driveway at the north end of the lot; however, this would result in multiple dead-end parking lot rows (Figure 22).

Scheme D

Spatial Layout

Scheme D is a combination of Schemes B and C. Most noticeable in this scheme are the multiple parking options given to users and the abundance of locations for trees, green areas, and bioswales outside the perimeter of the lot. This scheme is the second-least efficient in terms of surface area, but it is also the only scheme to offer parking to the west and south at the same time. Unlike schemes A and C, the parking lot is expandable to the west (SPiRiT point 8.C.2).

Pavement efficiency

Pavement Efficiency, in terms of % Impervious and % Pervious is: 57.2 percent impervious, 42.8 percent pervious (15,100 sq ft pavement, 11,300 sq ft porous surface, for a total of 26,400 sq ft).

Circulation Patterns (Including Buses, Semi Trucks, and Government Vehicles)

Similar to Scheme B, this scheme uses one entrance from Butner Road and one entrance that is shared with the main PWBC entrance. As in other schemes, buses would be able to enter the lot, drop off passengers, and exit without entering the compound (for night classes). The existing location of the PWBC entrance is the same size and shape as shown in schemes A and C.

Gate Design

To be determined.

Placement of Outdoor Classroom

The outdoor classroom will be located to the west of Building 2-2332 (Figure 22).

Size and Placement of Natural Areas and Bioswales

Natural areas are suggestions, and will be finalized through input from landscape architects at Savannah District. Bioswale sizes will need to be calculated after parking lot design is finalized and site grades are determined. This will be completed during the Design Development and Construction Documentation phases, which Savannah District will conduct.

Views

Because this scheme places the parking lot between Butner Road and Building 2-2332, trees will need to be limbed up to account for Force Protection guidelines.

Advantages/Disadvantages

Scheme D is an attractive design simply because it keeps the most spaces as close as possible to the building. The two main concerns are its inefficient use of pavement, and (as in Scheme B) the shared use of the PWBC entrance. Unless properly regulated through the use of a timed gate, this could be the cause of congestion at peak hours. As in Scheme C, this scheme could be made more efficient by eliminating the driveway at the north end of the lot; however, this would result in multiple dead-end parking lot rows (Figure 23).

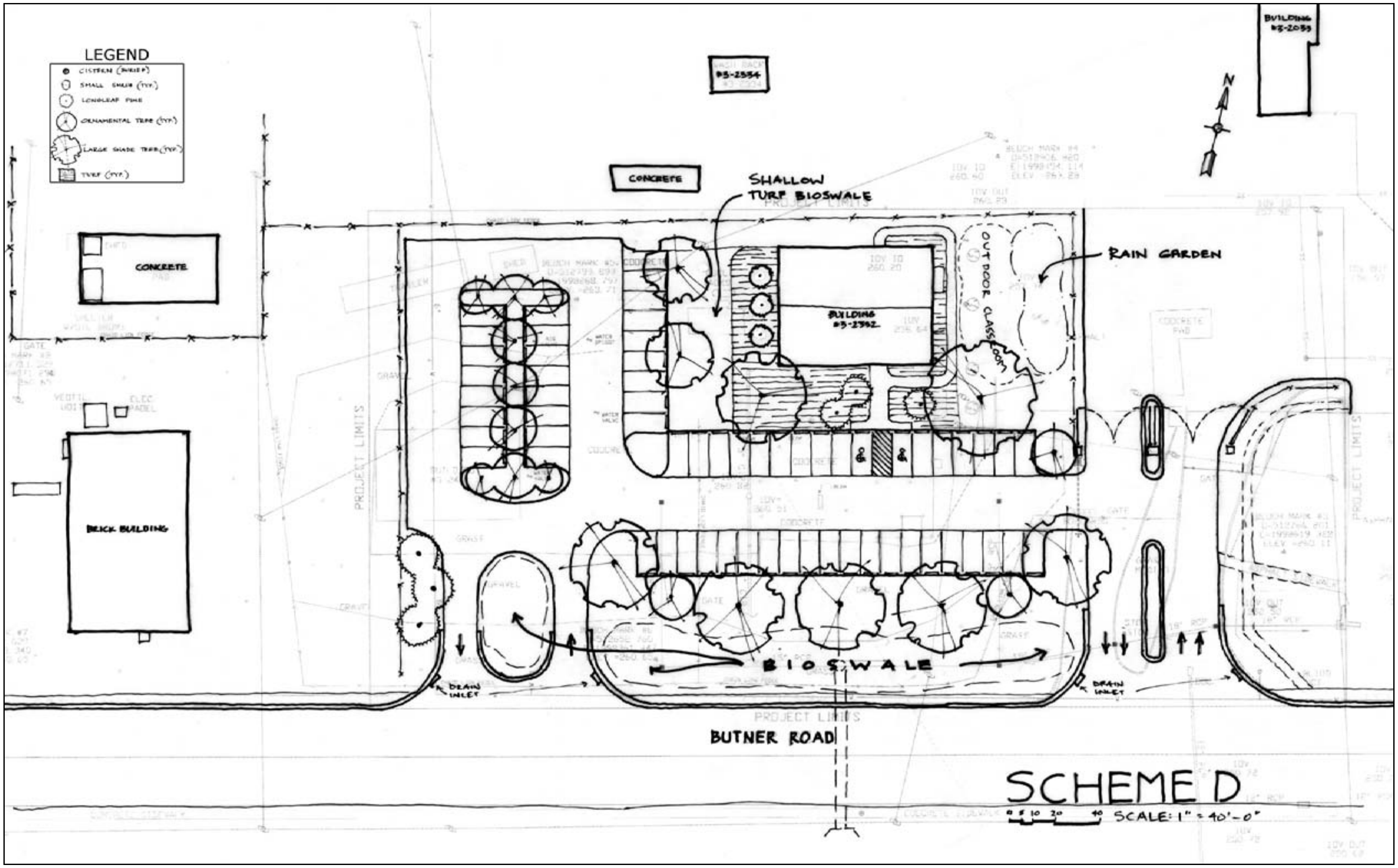

Figure 23. Scheme D (not to scale) keeps spaces close to the building, but uses pavement inefficiently, and shares use of the PWBC entrance.

5 Installation Comments on Schematic Designs

Although the Corps of Engineers has mandated the use of sustainable designs, the tools to adequately create a cost effective design are still being refined. This work was undertaken as part of that refinement process, to define and describe "what makes up" a sustainable parking lot, to document the charrette process and the goals set forth at Fort Bragg, and to present and explain several CERL designs for a sustainable parking lot.

Figures 24 through 29 show the comments received on the CERL sustainable parking lot designs. Each set of comments provides valuable input into the steps that still must be taken to design and build a sustainable parking lot for a given site — in establishing clear communication between the partners in the project.

AFZA-PW-E 22 March 2002

MEMORANDUM FOR FMD, ATTN: Ben Rhodes, CMD

SUBJECT: Sustainable Parking Lot, FW00086-2

1. Scheme A –Although parking lot is permeable it is unbroken with landscape islands. Please read IDG 2.5-4. No special landscape treatment at entrance to building. Read IDG.
2. Scheme B – Outdoor classroom will not function as designed. Read IDG regarding landscaped islands. No special landscape treatment at entrance to building. Read IDG. Integration of the pedestrian circulation system has not been included.
3. Scheme C – No special landscape treatment at entrance to building. Read IDG. Integration of the pedestrian circulation system has not been included. Turning radius of islands does not appear adequate for easy of negotiating. Recommend redesign of bays to achieve better double loading of isles.
4. Scheme D – Second split driveway is excessive. No special landscape treatment at entrance to building. Read IDG. Integration of the pedestrian circulation system has not been included.

In general, considering the quantity of trees shown in all schemes, the type and purpose should be shown. There seems to be confusion regarding quantity of pavement vs. quality of pavement. As long as the pavement is permeable, why does it matter how efficient it is regarding area and configuration? All schemes using the existing entrance present significant congestion problems.

Scheme C has merits as does the attached scheme A-1 with a more curvilinear parking lot. Scheme "C" offers pleasant landscape opportunities in front of the building. I understand the desire for a zero-scape environment however the front of a facility should not present a scraggly unkept look. Recommend grass, groundcover, perennial shrubs and trees with under-story.

JOHN ROSE, AIA
PWBC Architect

Figure 24. AFZA-PW-E responses to proposed sustainable parking lot designs.

30 Jan 02

Memorandum

TO: Annette Stumpf, Sustainable Design & Development Center, CERL

FROM: Benjamin Rhodes, AFZA-PW-C, Project Manager, CMD, PWBC

Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot

A concept meeting was performed on 30 Jan 02 between representatives of CMD, FMD, & ENRD here at Fort Bragg to discuss the five (5) concept drawings received from CERL for the subject project. Your attention is directed to the following highlights of this meeting:

1. GENERAL COMMENT (Consensus) - Based on review on the concept plans as presented and received on 25 Jan 02, a meaningful review could not be performed and as such a particular one concept of the 5 submitted could not be selected. This became apparent in the absence of the relationship of the concept(s) in relation to the existing features at the site.

2. We would like you to re-submit concepts coupled with consideration of the following:

   a. Consider providing separate entrance(s) to the classroom apart from the existing PWBC Compound main Butner Road entrance while retaining sustainable work/design for the existing main PWBC entrance and on parking area to the immediate east of the existing entrance (this is to remain in the scope).

   b. Consider providing parking in front of the Building (south) coupled w/ parking to the west (L shape). The consensus is that a parking lot is not feasible to the East of the building due to the needed width of the vehicle corridor through that area.

   c. Consider force protection by providing a minimum 30' distance from building to parking.

   d. We will need bus access. This bus access is needed not only for student pickup for tours, but for future mass transit considerations. Therefore it should be outside of the fence. The 30 foot F.P. distance would not apply for this [?is this true?].

   e. 60 spaces are needed for the training building west of the PWBC entrance. If additional spaces in the existing parking lot east of the main entrance is feasible when the entrance is redesigned, please incorporate.

Figure 25. AFZA-PW-C review comments on proposed sustainable design schematics.

Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot

f. Parking for the classroom is to be all on site and not the near by parking lot. Do not like the concept of mixing pedestrian and vehicular traffic.

g. Provide/consider provisions for motorcycle parking.

h. Clarify the bioswale, i.e., is this as "rain garden"? Would like to consider the garden concept with tiered landscaping from the outer perimeter of the swale to the center.

i. Use the existing concrete sidewalk to the extent possible and add to it in the design to show how it is tied to other areas of the compound (although work outside of project limits will not be done on this job, it is important to show how we need to tie in pedestrian traffic to the other areas). Consider the stormwater impacts from water off of the building on the existing sidewalks as well.

j. Scheme # 5 is a no go for sure as it encroaches into the compound toward the north.

k. Please provide/show a breakdown of the trees, vegetation, etc. shown, in particular for type, species, etc. with an explanation of how they add to the Compound. We do not have a detailed study to rely on.

l. Reference traffic circulation pattern drawn and given to you during the Charrette, this is our best shot at what we feel is the traffic behavior in and out of the Compound. We do not have a detailed traffic study to rely on.

m. Has lighting been addressed?

n. Building 3-2033 and location of the proposed fence line and how it ties in to the training building (we are assuming that the fence will be tied in to the rear Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot of the building on the east and west sides so that you can enter the building from either inside or outside of the compound), and existing fence must be shown/addressed.

o. Realignment/layout of the main entrance into the PWBC compound must be captured on this project. Entrance must be designed to handle tractor trailer trucks entering and leaving the compound, and aesthetically pleasing on the appropriate scale as the primary access for an installation Directorate. Brick columns with engineer castles or other entranceway architecture that captures the essence of army engineers should be included to tie it in to the main brick building and adjacent break area. If a center median is retained, appropriate landscaping needs to be included.

p. The training building needs some type of break area/outside sitting area designated (with sustainable landscaping).

Figure 25. (Cont'd).

Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot

q. At what point do we get some type of analyses that shows the sustainability principals considered, and either applied or dropped for this project? Part of the process needs to be a record/explanation/description of these elements. How were things like sun angles, bioswales, terrain features, species selection, project materials, etc. considered. Our understanding is that this information will be presented with the next submittal. Document should also capture the type of materials reused from project demolition and other reclaimed materials from Fort Bragg (crushed concrete, mulch, etc).

In addition to the above the following are review comments made prior to the aforementioned meeting and are offered for your attention:

Reviewer-BCR

SKETCHES

1. General Comments to all 5 schemes as presented.

2. The PWBC Project Number and title should be affixed to these sketches, i.e., "FW-00086-2, Sustainable Parking Lot, ENRD Classroom".

3. The North Arrow should be shown.

4. The "scale" or "No/Not to scale " should be stated/shown on each sketch (Also a Bar Graph should be shown).

5. A legend should be included on each sketch.

6. The name of the streets should be labeled.

7. The classroom building number should be shown.

8. Difficult to judge position/location of new work in relation to existing facilities, in particular in the absence of a scale (Bar Scale). In the absence of this relationship cannot ascertain if any possible offset in alignment of entrance exist, in particular with the new parking lot in front (East) of the classroom as shown on Schemes #1 & #3. This entrance needs to line up straight into the compound w/ no doglegging around new lot to go north

9. Into back of compound. These schemes show curb & gutter to extend eastward, which will block traffic, straight into back of compound.

10. The e-mailed schemes received on 22 Jan 02 were numbered 1, 2, & 3, but when printed were numbered 1, 3, % 4.

11. The PWBC Drawing Number assigned to this Project is 6208 and should be affixed. The final concept should be placed on Fort Bragg format drawing sheets for agency filing and have been attached to E-mail to CERL.

Figure 25. (Cont'd).

Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot

12. The sketches show only one-way traffic (arrows) at the main entrance onto Bunter and are questioned. If this is the same as the existing entrance, two-way traffic exists and is intended and should be identified.

13. With all of the trees (assumed) shown at the entrance is there adequate sight distance in order to safely pull out onto oncoming traffic along Butner Road? This could be really critical when the trees mature/grow and leaf out.

14. Buses will need to access the parking lot, in particular at night.

ESTIMATE

A preliminary estimate/opinion of probable cost associated with each scheme presented needs to be submitted (Ref: Scope of work for funding 500k limit) for review.

SPECIFICATIONS

Recommend submittal of cut sheets for such items as "grasscrete, porous pavers, etc. for review.

Reviewer/RG & TK

The DOD Antiterrorism/Force Protection Construction Standards specify the standoff distance (Camile Cole has a copy). When that standoff distance cannot be met, the design of the facility to be constructed has to be hardened. Parking lots and roadways have to be at least 30 feet from inhabited structures and 80 feet from troop billeting and primary gathering structures.

Reviewer-CC

1. All schemes mix vehicular and pedestrian traffic.
2. Need direct access to back of compound.
3. At least a 30' standoff distance must be maintained around the building, as this is an inhabited building.
4. Schemes 4 and 5 push the existing fence into our compound, which restricts vehicle movement in the east/west direction.
5. Existing structures need to be shown in order to perform a better and more thorough review.

Reviewer-TK

1. My biggest concern is that the parking may be too close to the building due to force protection requirements. We have several parking lots on Post that can no longer be used, or only partially used, because they are too close to the building.

Figure 25. (Cont'd).

Subject: CONCEPT DESIGN –30% Review Comments FW-00086-2, Sustainable Parking Lot

2. Recommend that CERL/AE coordinate with Mr. Greg Jackson, Public Safety Business Center, and Mr. Reid Gantt, Security & Intel Division, Public Safety Business Center (910-396-8292/3921) for the specific requirements.

3. I would also recommend getting the force protection requirements in writing for future projects.

Reviewer-EH

Recommend in the landscape plan planting longleaf pine where applicable.

Reviewer-KVB

1. Fence line, wash rack & building 3-2033 must be shown in all schemes.

2. Chosen plan must illustrate vehicle circulation inside the compound to ensure the overall plan works on both sides of the fence.

3. Provide an option that relocates the compound access/entrance to the west of the ed. building.

4. Double check existing parking lot dimensions so that we have an accurate idea of where the existing fence line needs to move to further in the compound.

5. Please attend to the sidewalk/pedestrian connection from the existing POV parking lot over to the ed building.

6. Scheme 5. Looks like it encroaches too far into the existing compound and internal vehicle circulation could be adversely effected.

Reviewer-JR

1. I expect more structure, more complexity and greater consideration of variables in a sustainable design. To date I have seen no more than normal. In fact, I have seen less focus and response to criteria and constraints.

2. A list titled "Essential Sustainable Design Studies (Drawings)" Submitted by John Rose, Post Architect will be faxed under separate cover for attention.

3. In view of the foregoing, please re-submit Concept Designs for this Project ASAP in order that the Project Schedule can be realized.

4. If you have any questions and/or require clarification of the above, please call me at (910) 396-4243 or e-mail me at rhodesb @bragg.army.mil.

Signed________________________

Benjamin Rhodes, Project Manager, CMD

Figure 25. (Cont'd).

I prefer SCHEME C with one entrance/exit. **NO ASPHALT/CONCRETE**

PAGE 6 para 2.2 should read **25 year** storm not 10 year!!!!!!

PAGE 10 para 3.2 sub para 3.2.1 pervious surfaces
Pervious asphalt and pervious concret is **NOT ACCEPTABLE**. I want pervious pavers i.e., UNI ECO-Stone (" March/April issue of "Storm Water").

PAGE 17 para 3.2.3
This is the type of underground retention to be used in conjunction with a sump pump to use the stored water for irrigation of lawn areas.

PAGE 18 para 3.2.6 Rain Gardens
Contact Greg Jennings at N.C. State University

PAGE 24 para 4.2
Design storm should read **25 year** NOT 10 year!!!!!!!!!

PAGE 4.3.1 PARKING LOT CONSTRUCTION AND DRAINAGE
"**NO ASPHALT**.............!!!!!!!!!!!!!"

Craig Lantz
Soil Conservationist/Storm Water

Figure 26. Soil Conservationist's review comments on proposed sustainable design schematics.

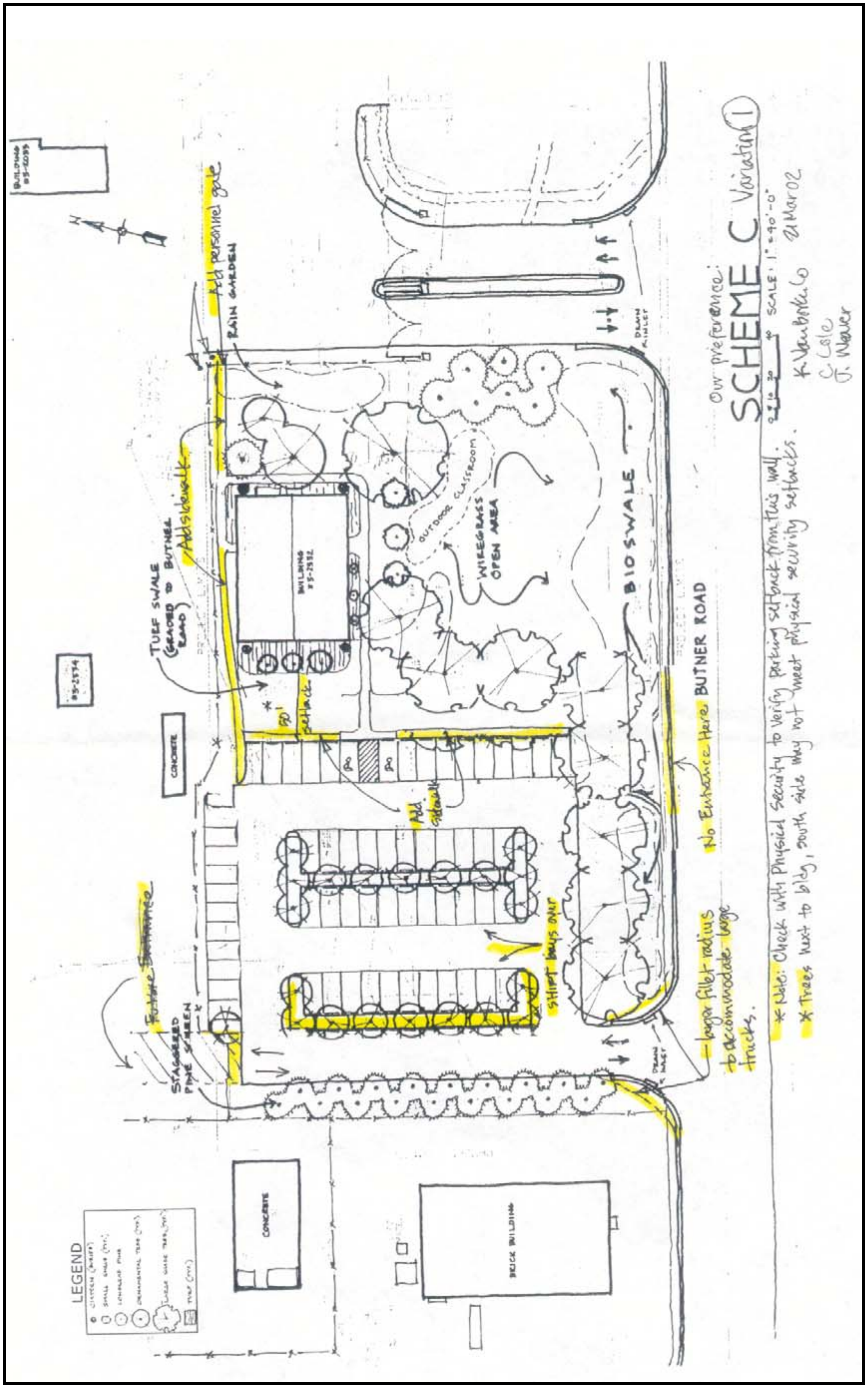

Figure 27. Schematic Design "C" with installation comments.

Ben

Per our conversation, I think they may have their directions off in some of the written comments. When they are saying north, I think they are meaning west (not really for sure). Any way, I like Scheme C

Danny F. Terry
Environmental Compliance Branch
Public Works Business Center
Phone (910) 396-3341 x-360
Fax (910) 396-4188

Figure 28. Environmental Compliance Branch review comments on proposed sustainable design schematics.

EBC Comments on Parking Design for Bldg 3-2232 – Mar 02

1. Check building number in document and on drawings. Building number should be 3-2232.
2. Section 1.3 Check grammar on last sentence in this section
3. Section2.2 Change 10 to 25 yr storm. Check and redo calculations if necessary
4. Section 2.3 Building numbers need hyphen after first digit i.e., 3-1634
5. Section 3.1.2 "On-site" can be defined as within Fort Bragg. Include option for using recycled concrete at landfill and mulch at landfill
6. Section 3.1.3 "Local material should be broadened to include 100-mile region that was previously stated in section 2.2. Need to be consistent.
7. What sustainable materials are available within 100 miles????
8. Include solar pump for irrigation from retained water.
9. Use solar and wind powered exterior lighting.
10. Section 4.2 Redo calculations for 25 year storm event
11. Does staggered pine screen along the fence line conform to Force Protection requirements?
12. Section 4.3.2 Redo calculations for 25 yr storm event
13. Scheme C – address exit door from classroom on the west side of the building … needs access to parking lot and clearance from landscaping.
14. Scheme C – need to address pedestrian traffic coming from within the PWBC compound. Add a pervious walkway to the side or front door. Consider adding a sidewalk inside the fence.
15. PWBC should consider extending the project limits to the edge of the concrete loading ramp on the N side of the building. The elevation of existing manholes already obstructs that thoroughfare.
16. Add a bike rack and motorcycle parking.
17. There are drain inlets shown on the driveways. Should be a culvert underneath that has a grate or slit-drain on top to catch any runoff from the parking area. Culvert should dump water into the bioswale or into the underground retention tanks.
18. Add some landscaping on the North end of fence adjacent to the parking area.
19. What is the distance between the building foundations and the cisterns?
20. Are cisterns above or below ground?
21. How does water get out of the cistern?
22. Need a better idea of the irrigation system concept.
23. Which species are droughts tolerant? Which are "wet" plants? Indicate which are annuals and which are perennials.

Figure 29. EBC review comments on proposed sustainable design schematics.

EBC Comments on Parking Design for Bldg 3-2232 – Mar 02 (Cont'd)

24. PWBC needs to address issue of distance between fence and back of building. Does there need to be room for a fire truck to get behind?
25. How does the landscaping plan use integrated pest management?
26. Must work with John Rose to address the East side of the Entrance. This has not been addressed in any of the schemes.
27. Is a new personnel gate needed on the east side of the gate?
28. Use landscaping to screen outdoor classroom from the road.
29. Recommend use of recycled lumber for the outdoor classroom (~20 people).

Figure 29. (Cont'd).

6 Conclusions and Lessons Learned

Conclusions

This collaboration between CERL, Fort Bragg, Savannah District, and the Omaha District Transportation Systems Center has provided design schematics for a sustainable parking lot adjacent to Building at 2-2332, Fort Bragg, NC. The design schematics address classroom needs and sustainable design requirements. They also recommend strategies for incorporating sustainable design into the overall project site. A broader, underlying objective was also met — all project participants came away with a better understanding of issues related to storm water control problems on an installation with a densely paved cantonment area.

At this writing, the sustainable parking lot described in this report has not been awarded for construction. Consequently, a final SPiRiT rating cannot be determined. During the next fiscal year, the construction documents will be developed and a construction project awarded. An analysis of the project site and schematic design documents has shown the potential for a Silver SPiRiT rating. However, this high rating can only be achieved if the project is designed and developed in accordance with the concepts described in this report.

Lessons Learned

Several lessons were learned during the development of the schematic design for the sustainable parking lot.

1. Future design charrettes should begin with an introduction to sustainability to allow the entire project team to achieve a common understanding of applicable sustainability concepts. It is important for all team members to share a vision of the project outcome.
2. Future design charrettes should include early discussion of the overall process to bring participants in the project not previously involved in design and construction projects "up to speed." This process improvement should explicitly define roles and responsibilities, and desired outcomes. The Fort Bragg parking lot project set target deadlines, yet not all participants shared a consistent understanding of the deliverables for each phase of the project.

3. The design charrette review process should use an automated project review tool to allow each review team member to enter individual review comments. These review comments may then be consolidated/verified by the review manager prior to release. In this case, the CERL schematic design team and Savannah District design team could have responded directly to each comment. This process step could have improved communication on design issues. (DrChecks, a web-based project review tool available to each Corps of Engineers District for project reviews, is tailored to serve this function.)*
4. Design and construction of sustainable parking lots requires a paradigm shift. New concepts require different calculation procedures, use of unfamiliar materials, a change in demolition and construction practices, and careful thought to integrate all the design concepts into the end project. This can take more time than expected because the project team members need time to think and understand the implications of each design decision. Once the sustainable parking lot has been designed, specified, awarded, and constructed, the lessons learned during the project should be shared with other Army Installations and Corps District offices. The Omaha District Transportation Systems Center can play a role in disseminating the project lessons learned.
5. The ideas contained in this report may be applicable to other new and renovated parking lots. Additional good ideas, best management practices, guidance, and case studies can be found on the Internet.

* More information on DrChecks can be found at http://www.projnet.org).

Appendix A: Fort Bragg Long-Term Sustainability Goals

1. Reduce amount of water taken from Little River by 70 percent by 2025, from current withdrawals of 8.5 million gal/day.
2. All water discharged from Fort Bragg will meet or exceed North Carolina state high quality water (HQW) standard, by 2025.
3. Landfill waste to be aggressively reduced toward 0 (zero) by 2025.
4. Meet minimum platinum standard for all construction by 2020 program, and renovate 25 percent of all existing structures to at least a bronze standard by 2020.
5. Adopt compatible land use laws/regulations with local communities by 2005.
6. Eliminate energy waste, by giving Commanders energy goals and data on actual energy use, by 2002 (still to be revised).
7. Develop acceptable regional commuting options, by 2025 (to be combined with 8).
8. Operate 100 percent of nontactical fleet on alternative fuels by 2010 (to be combined with 7).
9. Develop an integrated environmental education program for Fort Bragg, its surrounding communities and interested parties.
10. Work towards 100 percent EPP by 2025 for all purchases, including IMPAC, contract, and MILSTRIP.

Appendix B: SPiRiT Rating Checklist

1.0	Sustainable Sites	Realistic	Ideal	Max
		14	15	20
1.R1.1	Erosion, and Sedimentation and Water Quality Control.			[Required]
1.C1.1	Site Selection: Avoid development of inappropriate sites.	1	1	1
1.C1.2	Site Selection: Select site based on functional adjacency and land use compatibility.	1	1	1
1.C2.1	Installation/Base Redevelopment: Increase localized density.	0	0	1
1.C2.2	Installation/Base Redevelopment: Select sites close to existing roads and utilities.	1	1	1
1.C3.1	Brownfield Redevelopment.	0	0	1
1.C4.1	Alternative Transportation: Installation/base transit system access.	1	1	1
1.C4.2	Alternative Transportation: Provide bicycle racks and changing/shower facilities	1	1	1
1.C4.3	Alternative Transportation: Locate near alternative-fuel refueling stations.	1	1	1
1.C4.4	Alternative Transportation: Size parking capacity and provide preferred parking.	1	1	1
1.C5.1	Reduced Site Disturbance: Protect OR restore previously developed sites.	0	0	1
1.C5.2	Reduced Site Disturbance: Reduce the development footprint.	0	1	1
1.C6.1	Stormwater Management: Implement a stormwater management plan.	1	1	1
1.C6.2	Stormwater Management: Implement EPA’s Best Management Practices.	1	1	1
1.C7.1	Landscape and Exterior Design to Reduce Heat Islands: Provide shade on the site.	1	1	1
1.C7.2	Landscape and Exterior Design to Reduce Heat Islands: Energy Star compliant roof.	0	0	1
1.C8.1	Light Pollution Reduction.	1	1	1
1.C9.1	Optimize Site Features.	*1*	*1*	1
1.C10.1	Facility Impact: Cluster facilities to reduce site impact and support mass transit.	0	0	1
1.C10.2	Facility Impact: Identify and mitigate potential impacts beyond site boundaries.	1	1	1
1.C11.1	Site Ecology.	1	1	1

2.0	Water Efficiency	Realistic	Ideal	Max
		3	**3**	**5**
2.C1.1	Water Efficient Landscaping: Use technology OR capture or recycle site water.	1	1	1
2.C1.2	Water Efficient Landscaping: Use only captured or recycled water; no irrigation system.	1	1	1
2.C2.1	Innovative Wastewater Technologies.	1	1	1
2.C3.1	Water Use Reduction: Reduce water use by 20%.	0	0	1
2.C3.2	Water Use Reduction: Reduce water use by 30%.	0	0	1

3.0	Energy and Atmosphere	Realistic	Ideal	Max
		1	**3**	**28**
3.R1.1	Fundamental Building Systems Commissioning.			[Required]
3.R2.1	Minimum Energy Performance (TI 800-01).			[Required]
3.R3.1	CFC Reduction in HVAC&R Equipment			[Required]
3.C1.1	Optimize Energy Performance: 1 point per 2.5% energy reduction (from baseline).	0	0	20
3.C2.1	Renewable Energy: 5% on-site renewable energy system.	0	0	1
3.C2.2	Renewable Energy: 10% on-site renewable energy system.	0	0	1
3.C2.3	Renewable Energy: 15% on-site renewable energy system.	0	0	1
3.C2.4	Renewable Energy: 20% on-site renewable energy system.	0	0	1
3.C3.1	Additional Commissioning.	0	***0***	1
3.C4.1	<<Deleted>>			
3.C5.1	Measurement and Verification.	0	1	1
3.C6.1	Green Power.	***1***	1	1
3.C7.1	Distributed Generation.	0	1	1

4.0	Materials and Resources	Realistic	Ideal	Max
		4	**8**	**13**
4.R1.1	Storage & Collection of Recyclables.			[Required]
4.C1.1	Building Reuse: Maintain at least 75% of existing building structure and shell.	0	0	1
4.C1.2	Building Reuse: Maintain 100% of existing building structure and shell.	0	0	1
4.C1.3	Building Reuse: Maintain 100% of existing building structure, shell and 50% nonshell systems.	0	0	1
4.C2.1	Construction Waste Management: Recycle and/or salvage at least 50% of waste.	1	1	1
4.C2.2	Construction Waste Management: Recycle and/or salvage at least 75% of waste.	0	1	1
4.C3.1	Resource Reuse: Specify salvaged or refurbished materials for 5% of building materials.	1	1	1
4.C3.2	Resource Reuse: Specify salvaged or refurbished materials for 10% of building materials.	1	1	1
4.C4.1	Recycled Content: Specify 25% of materials that contain post-consumer recycled content.	1	1	1
4.C4.2	Recycled Content: Specify 50% of materials that contain post-consumer recycled content.	0	1	1
4.C5.1	Local/Regional Materials: Specify a minimum of 20% building materials that are made locally.	***0***	1	1
4.C5.2	Local/Regional Materials: Of these (20%) a minimum 50% that are obtained locally.	0	1	1
4.C6.1	Rapidly Renewable Materials.	0	0	1
4.C7.1	Certified Wood.	0	0	1

5.0	Indoor Environmental Quality (IEQ)	Realistic	Ideal	Max
		0	**0**	**17**
5.R1.1	Minimum IAQ Performance.			[Required]
5.R2.1	Environmental Tobacco Smoke (ETS) Control.			[Required]
5.C1.1	IAQ Carbon Dioxide (CO2) Monitoring.	0	0	1
5.C2.1	Increase Ventilation Effectiveness.	0	0	1
5.C3.1	Construction IAQ Management Plan: During construction IAQ requirements.	0	0	1
5.C3.1	Construction IAQ Management Plan: Before occupancy IAQ requirements.	0	0	1
5.C4.1	Low-Emitting Materials: Adhesive & Sealants.	0	0	1
5.C4.2	Low-Emitting Materials: Paints.	0	0	1
5.C4.3	Low-Emitting Materials: Carpets.	0	0	1
5.C4.4	Low-Emitting Materials: Composite wood.	0	0	1
5.C5.1	Indoor Chemical and Pollutant Source Control	0	0	1
5.C6.1	Controllability of Systems: Provide high level of occupant perimeter controls.	0	0	1
5.C6.1	Controllability of Systems: Provide high level of occupant nonperimeter controls.	0	0	1
5.C7.1	Thermal Comfort: Provide shade on the site.	0	0	1
5.C7.2	Thermal Comfort: Use Energy Star compliant roofing OR install a green roof.	0	0	1
5.C8.1	Daylight and Views: 2% Daylight Factor in 75% of all occupied spaces.	0	0	1
5.C8.2	Daylight and Views: Line of sight to vision glazing in 90% of all occupied spaces.	0	0	1
5.C9.1	Acoustic Environment/Noise Control.	0	0	1
5.C10.1	Facility In-Use IAQ Management Plan.	0	0	1

6.0	Facility Delivery Process	Realistic	Ideal	Max
		7	**7**	**7**
6.C1.1	Holistic Delivery of Facility: Choose leaders with holistic project delivery experience.	1	1	1
6.C1.2	Holistic Delivery of Facility: Train PDT in the holistic delivery process.	1	1	1
6.C1.3	Holistic Delivery of Facility: Identify project goals and metrics (PMP).	1	1	1
6.C1.4	Holistic Delivery of Facility: Plan & execute charrettes with team members.	1	1	1
6.C1.5	Holistic Delivery of Facility: Identify and resolve conflicts in project requirements.	2	2	2
6.C1.6	Holistic Delivery of Facility: Document required deliverables that achieve project goals.	1	1	1

7.0	Current Mission	Realistic	Ideal	Max
		3	**3**	**6**
7.C1.1	Operation and Maintenance: Develop a facility operations and maintenance program.	2	2	2
7.C1.2	Operation and Maintenance: Provide durable material surfaces, furnishings & equipment.	1	1	1
7.C2.1	Design for Soldier & Workforce Productivity & Retention: Enhance user's quality of life.	0	*0*	1
7.C2.2	Design for Soldier & Workforce Productivity & Retention: Promote work productivity.	0	0	1
7.C2.3	Design for Soldier & Workforce Productivity & Retention: Sustain QOL & productivity.	0	0	1

8.0	Future Missions	Realistic	Ideal	Max
		2	**2**	**4**
8.C1.1	Assess the Lifespan of the Designed Use and Supporting System: Identify function life.	1	1	1
8.C1.2	Assess the Lifespan of the Designed Use and Supporting System: Identify systems life.	1	1	1
8.C2.1	Design for Adaptation, Renewal and Future Uses: Design for flexibility.	0	*0*	1
8.C2.2	Design for Adaptation, Renewal and Future Uses: Design today for tomorrow.	*0*	*0*	1

				Max
		34	41	100

Appendix C: Reference Information

Stormwater Management

http://www.kristar.com/about.html

http://www.stormwater-products.com/index.htm

http://www.hydrocompliance.com/

http://www.rinkermaterials.com/stormceptor/index.htm

http://www2.state.id.us/deq/water/stormwater_catalog/index.asp

http://www.invisiblestructures.com/RS3/rainstore.htm

http://www67.homepage.villanova.edu/clay.emerson/Links.htm

Brouwer, Greg. "Storm-Water Management - University Demonstrates Sustainable Storm-Water Concepts," *Civil Engineering* (September 2002), pp 18-19; a website on the project at Villanova University is available at URL:

www.engineering.villanova.edu/cee/vusp

Bioswales

http://www2.state.id.us/deq/water/stormwater_catalog/doc_bmp38.asp

http://www.stormwatercenter.net

Claytor, Richard A. and Schueler, Thomas R. *Design of Stormwater Filtering Systems.* Center for Watershed Protection, Inc. Ellicott City, MD, 1996.

Porous Paving

http://www.stormwatercenter.net/

http://humatech-inc.com/

http://www.ecsgreen.com/index.html

http://www.rehbein.com/template.cfm/1

http://www.stabilizersolutions.com/

http://www.invisiblestructures.com/GP2/grasspave.htm

http://www.netlon.co.uk/_turfsystems/introduction.htm

http://www.ecsgreen.com

Bay Area Stormwater Management Agencies Association (BASMAA). Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection. BASMAA, San Francisco, CA. January 1997.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices: 2nd Edition. Center for Watershed Protection. Ellicott City, MD.

Cisterns

http://saferain.hypermart.net/roofwasher.htm

http://www.plastmo.com/rbdivert.html

http://www.cmac.com.au/waterdiv.htm

Energy Efficient Lighting

http://www.cleanenergy.de/companies/airtherm/light.html

http://www.solardyne.com/solpowlig.html

Appendix D: Partial List of Suggested Landscaping Plants

General Landscaping

Trees	**Shrubs:**	**Rain Garden Forbs**
Longleaf pine	Abelia	Red milkweed
Loblolly pine	Acuba	Shooting star
Crabapple	Azaleas	Wild iris
Crapemyrtle	Barberry	Nodding pink onion
Dogwood	Hibiscus	Prairie blazing star
Turkey oak	Holly	New England aster
White oak	Indian hawthorn	Ohio goldenrod
Red oak	Inkberry	Sweet black-eyed susan
Southern live oak	Kalmia	
Persimmon	Photina	
Sourwood	Pittosporum	
Red maple	Privet	
	Rhododendrens	
	Serviceberry	
	Viburnum	
	Weigela	
	Yew	
	Persimmon	
Rain Garden Grasses	**Wet Bioswale (occasionally wet feet)**	**Emergent (feet in permanent pool)**
Indian grass	Blue lobelia	Blue flag iris
Prairie drop seed	Boneset	Marsh marigold
Cardinal flower	Fox sedge	Pickerelweed
Hosta	Joe Pye weed	Cattails
Orange coneflower	Ironweed	Water plantain
Salvia	Meadowrue	Wapato duck potato
Siberian iris	New England aster	Horsetails
	Porcupine sedge	Sweet flag
	Red cardinal flower	Softstem bulrush
	Red milkweed	
	Switchgrass	
	Turtlehead	

Appendix E: The MoonCell Luminaire Street Lamp

This off-grid, stand alone street light (Figure E1) is battery powered and uses both wind and solar energy to recharge the battery. The unit is:

- self contained
- weatherproof
- designed to withstand 200 mph winds
- combines solar and wind power generation
- provides bright, efficient alternative to grid powered street lamps, common area, parking lot, and residence lighting).

For more details, please see the.pdf file on:

http://www.mooncellusa.com

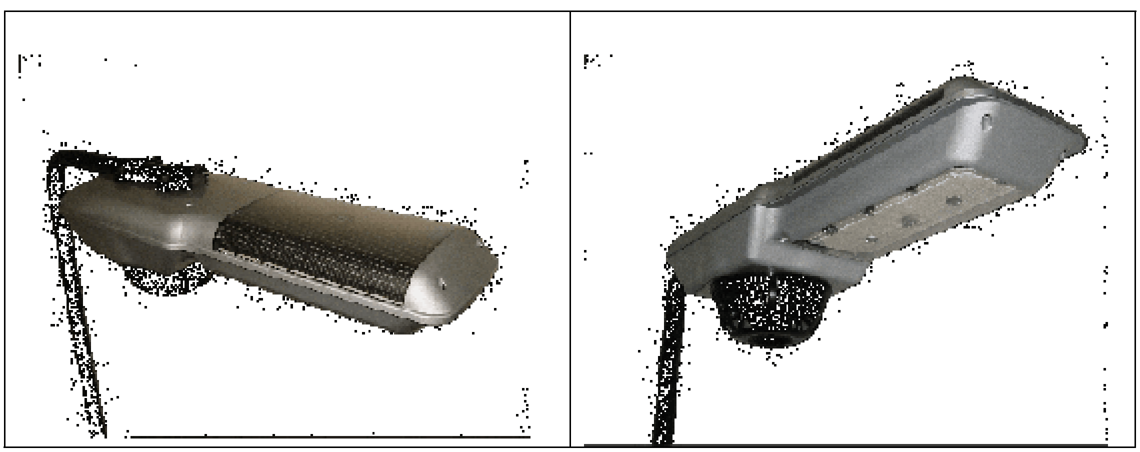

Figure E30. The MoonCell luminaire.

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14. ABSTRACT

Standard parking lots constructed with traditional techniques of impervious pavement (typically concrete and asphalt) are associated with a host of inherent problems: runoff problems, heat buildup, air pollution, light glare, and poor aesthetics. When planners at Fort Bragg, NC identified the need for a new parking lot for an installation classroom building, the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) was tasked with planning a sustainable design "charrette" to explore and develop alternative parking lot designs that would meet Fort Bragg's parking needs, as well as its need to meet sustainable design requirement and to alleviate the installation's water runoff problem. This effort provided four design schematics for a sustainable parking lot to meet classroom needs and design sustainability requirements, and recommended strategies for incorporating sustainable design into the overall project site.

15. SUBJECT TERMS

design	environmental planning	Ft. Bragg, NC
construction	maintenance and repair	sustainable design

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Unclassified	Unclassified	Unclassified	SAR	80	19b. TELEPHONE NUMBER (include area code) (217) 352-6511, X-7542

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